

Middle Cambrian trilobites from the Sosink Formation, Derik–Mardin district, south-eastern Turkey

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Synopsis

Trilobites from thin limestone beds in the lowest 225 m of the type section of the Sosink Formation SE of Derik include: *Peronopsis fallax* (Linnarsson 1869) aff. *minor* (Brögger 1878), *Solenopleuropsis marginata marginata* Sdzuy 1958, *Conocoryphe* (*Conocoryphe*) *caecigena* sp. nov., *Dorypyge terneki* sp. nov., *Paradoxides* (*Eccaparadoxides*) *remus* sp. nov., *P. (E.) cf. pradoanus* de Verneuil & Barrande 1860, *Paradoxides* (s.l.) *pentagonalis* sp. nov., *Chelidonocephalus anatolicus* sp. nov. and *Derikaspis toluni* gen. et sp. nov. The affinities of the fauna are largely with the western Mediterranean region, where *Derikaspis* occurs only in the Montagne Noire, SW France, but elements from Iran are also represented. A late, but not latest, Middle Cambrian age is postulated.

Introduction

The Derik–Mardin area (Fig. 1) lies between the rivers Tigris (or Dicle) and Euphrates (or Fırat) in south-eastern Turkey, about 75 km south of Diyarbakır and 25 km north of the Turkish-Syrian border. Much of the higher ground between Derik and Mardin is occupied by conspicuous outcrops of Cretaceous and Tertiary limestones, overlain by extensive Quaternary basalts which occupy the stony lower ground. Lower Palaeozoic, particularly Cambrian, rocks, transgressed by unconformable Cretaceous deposits, form a series of narrow inliers, elongated E–W, which extend some 20 km eastwards from near Derik. Knowledge of the local stratigraphy dates from 1934 when H. F. Moses produced a report on the Mardin–Cizre region for Maden Tetkik ve Arama (= M.T.A.), Ankara. Although officially unpublished, this pioneer work was quoted subsequently by Tolun & Ternek (1952) and by Tolun (1960), and a N–S cross-section (Mazı Dağ to Harabon Dağ) extracted from it was published by van der Kaaden (1971). Moses was the first to collect trilobites in the area but details of his discovery were never published, though his small collection was submitted to Professor B. F. Howell and recognized by him as being of Cambrian age. Mrs Phyllis Hasson, Princeton University, kindly allowed me to examine this material, which clearly corresponds to the fauna described in the present paper but is scanty and carries no detailed locality data. Tolun & Ternek (1952) collected further material and their paper included preliminary determinations by C. J. Stubblefield. The most important work dealing with the geology of the area is a comprehensive report by Kellogg (1960); though officially unpublished, it was nevertheless widely circulated, and thanks to the officials of M.T.A. I was able to consult the relevant portions.

Stratigraphy

The lithostratigraphic succession adopted here for the older rocks of the Derik area is as follows:

Bedinan Formation
 ~~~~~unconformity~~~~~  
 Sosink Formation  
 Koruk Formation  
 Sadan Formation  
 Derik Formation

*Derik Formation.* Base not seen. Comprises mostly volcanic rocks and corresponds to Derik Volcanics of Kellogg (1960), who postulated a thickness of 488+ m. Formational status, with a thickness of more than 2000 m, was accorded by Rigo de Righi & Cortesini (1964 : 1913) and by Schmidt (1965). Ketin (1966 : 77–80; pl. I) gave the same thickness but termed the unit Telbismi Formation, a name here considered best abandoned because it had been used earlier by Kellogg (1960) for reddish sandstones and shales corresponding to the present Sadan Formation.

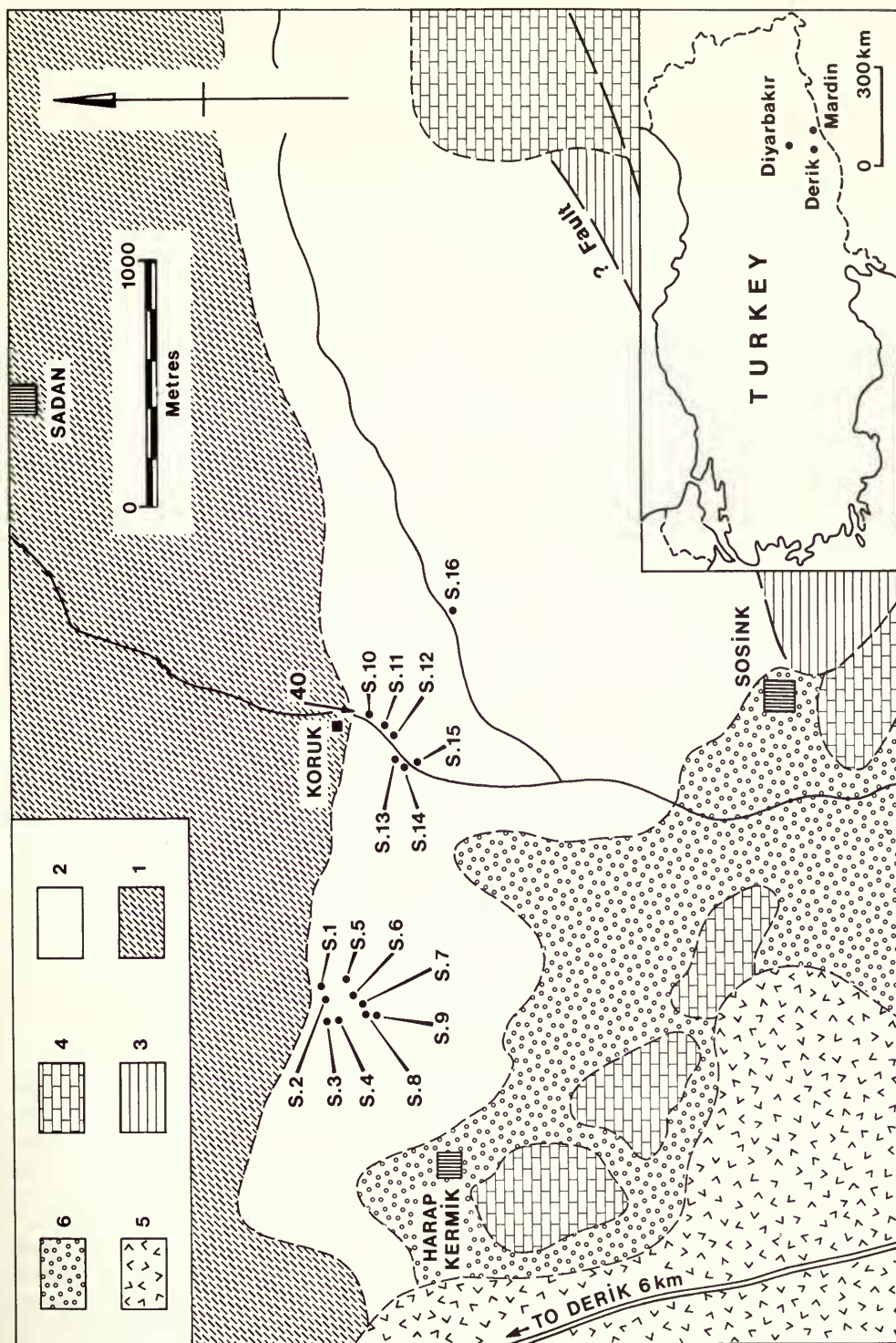


Fig. 1 Sketch map showing fossil localities in the Sosink Formation at two sections in the area NW and north of Sosink village. Inset map shows geographical position of the area in SE Turkey. Key to lithostratigraphic units: 1, Sadan Formation and Koruk Formation (undifferentiated). 2, Sosink Formation. 3, Bedinan Formation. 4, Limestones of Cretaceous and Tertiary age (undifferentiated). 5, Quaternary basalts. 6, Recent deposits.



*Sadan Formation.* Introduced by Rigo de Righi & Cortesini (1964 : 1913) for 300 m (apparently an underestimate) of conglomerates, coarse sandstones and redbeds. Corresponds broadly to the now abandoned Telbesmi (originally Telbismi) Formation, 584 m thick, of Kellogg (1960). A thickness of 685 m was given by Ketin (1966 : 77–80), who used also the notation  $C_1$ , and the unit is approximately equivalent to Schmidt's (1965) combined 'Sadan Redbeds Fm' and 'Zabuk Qtzt/Ss Fm', for which no thickness was indicated.

*Koruk Formation.* Used first as 'Koruk Ls/Dol Fm' by Schmidt (1965) and equivalent to the Sadan Dolomite, 243 m thick, of Kellogg (1960). The unit was not differentiated by Rigo de Righi & Cortesini (1964 : 1913), who apparently included it (as '250 m intercalated lsts and dolomites') within the Sosink Formation as interpreted by them. Ketin's (1966 : 79) 'Dolomite formation ( $C_2$ )' appears to match exactly with Schmidt's (1965) 'Koruk Ls/Dol Fm' and should not be confused with Ketin's (1966 : 80) 'Sosink or Koruk formation ( $C_3$ )', which corresponds to the present usage of Sosink Formation *sensu stricto*. The Koruk Formation is named after a group of buildings, unused in summer, sited 1.8 km north of Sosink village (Fig. 1); the type section is in the banks of the immediately adjacent stream valley. During my visit in 1979 with geologists of T.P.A.O. it was agreed informally to draw the Koruk/Sosink formational boundary at the base of a sequence of shales and siltstones, and immediately above a 13.6 m limestone unit which succeeds the yellow-grey weathering dolomites that constitute the greater part of the Koruk Formation.

*Sosink Formation.* Introduced by Kellogg (1960) for a unit of shales which passes upwards into siltstones and sandstones, often massive and cross-bedded, in the area north and north-east of Sosink, where he measured a total thickness of 1057 m. The stream valley running south from Koruk to Sosink (Fig. 1) may be considered as type section. The unit corresponds to 'Sosink Ss/Sh Fm' of Schmidt (1965) and 'Sosink or Koruk Formation ( $C_3$ )', 1120 m thick, of Ketin (1966 : 80), but includes only the highest 1700 m (probably an overestimate) of the Sosink Formation as interpreted by Rigo de Righi & Cortesini (1964 : 1913).

The succeeding Bedinan Formation, introduced by Kellogg (1960) for an Ordovician shale sequence at Bedinan village, 15 km east of Sosink, has remained constant in usage, though its relationship to the Sosink Formation has been subject to different interpretations. It has been variously regarded as conformable (Rigo de Righi & Cortesini 1964 : 1913, Ketin 1966 : 80) or questionably conformable (Schmidt 1965). Kellogg's (1960) original assertion of a disconformity has been borne out by subsequent researches, and the fauna of the Bedinan Formation, both at Bedinan and near Sosink, indicates a mid-Caradocian age for at least part of the unit (Dean 1967). A Sosink/Bedinan formational disconformity claimed by Kellogg (1960) at Şip Dere, 7 km ENE of Sosink, has been confirmed and shown to be of considerable magnitude; the faulted relationship north-east of Sosink as shown by him, and used questionably in the present paper (Fig. 1), is less clear owing to lack of exposures.

The town of Derik is sited on the south flank of a plateau formed by Cretaceous limestones (Mardin Formation) which unconformably overlie southerly-dipping Derik Volcanics, or Derik Formation. The latter are succeeded to the south by resistant rocks of the Sadan Formation and the Koruk Formation, which often form conspicuous hills; these strata are followed in turn by more regressively-weathering shales of the lower Sosink Formation which give rise to a gently undulating topography. In the area north of Sosink village the Sosink Formation is up to 1100 m thick; the lowest third comprises silty shales and fine-grained sandstones with occasional thin bands of limestone which may sometimes be traced for tens of metres along the strike but generally die out horizontally. The limestones include some calcarenites in which glauconite may be abundant, but micrites and whitish, sparry limestones also occur. Fossils mostly comprise disarticulated and broken trilobite remains such as those described here, but some inarticulate brachiopods occur. Sometimes the trilobite fragments are so small as to preclude generic identification, but in general the



material has suffered little distortion or compression and details of surface ornamentation are often preserved. Ascending the succession, the limestone horizons come to an end and the rocks become coarser, with frequent, massive beds of current-bedded sandstone. Occasional beds of silty shale are interbedded with the sandstones, and the trilobites *Holasaphus* (Dean 1972) and poorly-preserved agnostids were found in approximately the middle part of the Sosink Formation, most of which is unfossiliferous.

### Acknowledgements

Collecting by Janette Dean and myself would have been impossible without the kindness, co-operation and hospitality of numerous Turkish friends and colleagues, particularly from Maden Tetkik ve Arama, Ankara. The then director, Dr Sadretin Alpan, granted us the facilities of his organization, and in Ankara Dr Cahide Kırışlı helped us obtain relevant geological literature; in the field we were ably guided by Mr Günel Aygün, as well as by Mr Abdurrahman Tunç of Derik. My subsequent visit to the area in 1979 was made possible thanks to the co-operation of geologists of T.P.A.O., Ankara. At Princeton University, Mrs Phyllis Hasson kindly made available the original collection of H. F. Moses. I am much indebted to Dr A. W. A. Rushton (I.G.S., London) for reading the manuscript and making suggestions for its improvement. Mrs Margaret Millen prepared the text-figures from my drawings, Mr Peter Green (British Museum (Natural History)) took the photographs, and Dr Mu Xi-nan translated relevant passages published in Chinese.

### Systematic descriptions

The terminology employed here follows for the most part the Treatise on Invertebrate Paleontology (Harrington, Moore & Stubblefield, *in* Moore 1959 : O117). Terms for agnostids are essentially those of Palmer (1955 : 88), with minor modifications proposed by Whittington (1963 : 27). The use of 'median plectrum' is that of Öpik (1967 : 58), and the interpretation of this term, 'border furrow' and 'false border furrow' in *Chelidonocephalus* and *Derikaspis* follows Fortey & Rushton (1976 : 335–337).

All the material is from the Sosink Formation NW or north of Sosink, Turkey, and locality numbers (prefixed S.) refer to the sections shown in Figs 1 and 2, showing their geographical position and stratigraphic level respectively. Specimen numbers prefixed It. are housed in the Department of Palaeontology, British Museum (Natural History), London; material prefixed MTA is in the collection of Maden Tetkik ve Arama, Ankara.

Dimensions are given in mm; those marked \* are estimated.

Class **TRILOBITA** Walch, 1771

Family **QUADRAGNOSTIDAE** Howell, 1935

Genus **PERONOPSIS** Hawle & Corda, 1847

TYPE SPECIES. By monotypy, *Battus integer* Beyrich, 1845.

*Peronopsis fallax* (Linnarsson, 1869) aff. *minor* (Brögger, 1878)

Figs 3a–d, 4, 5

1946 *Peronopsis fallax minor* (Brögger, 1878); Westergård: 38, pl. 3, figs 3–7. Includes original synonymy.

FIGURED MATERIAL. It.2107 (Figs 3a–d), It.2108 (Fig. 4), It.2110 (Fig. 5).

HORIZONS AND LOCALITIES. All the illustrated specimens are from 80 m above the base of the Sosink Formation, at loc. S.4. On the basis of one incomplete cephalon (It.2111) the species is recorded questionably from loc. S.8, 155 m above the base of the Sosink Formation.

OTHER MATERIAL. Ten unfigured cephalata and eight pygidia, mostly fragmentary, from S.4.

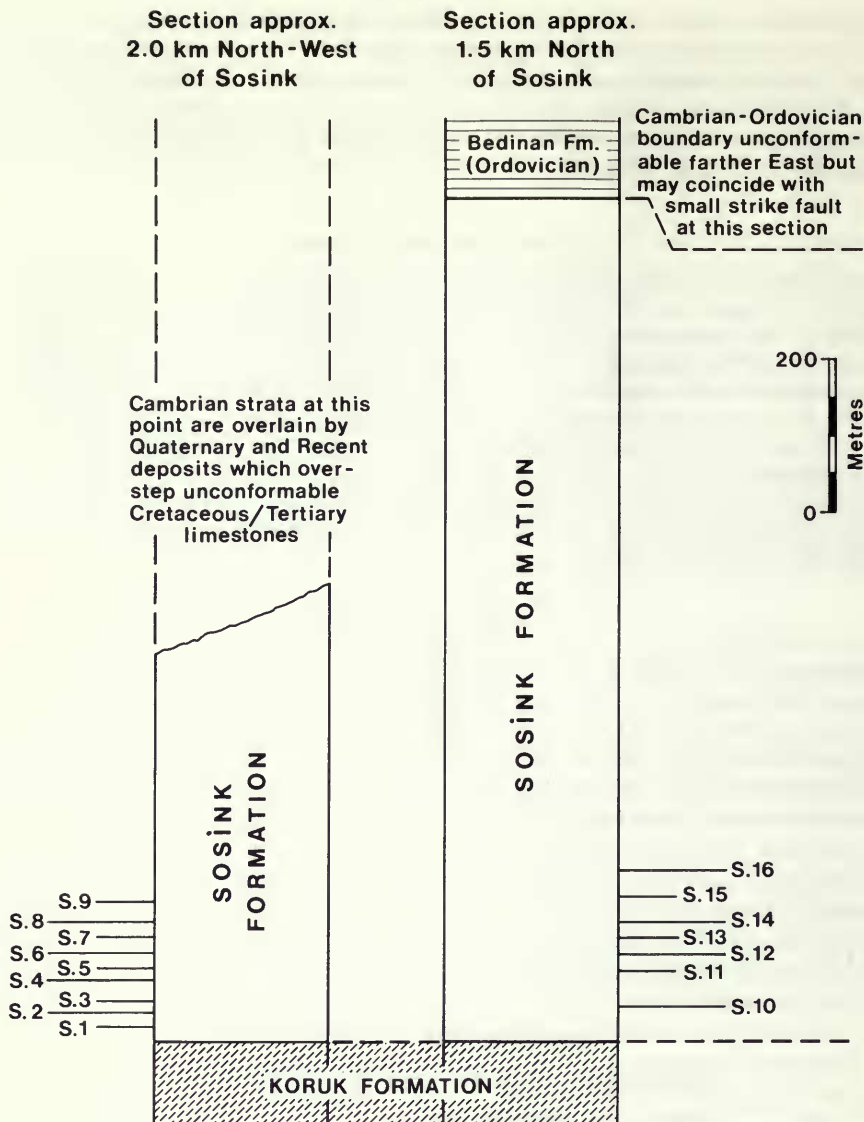
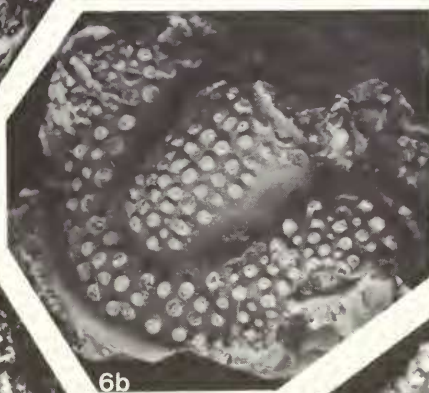
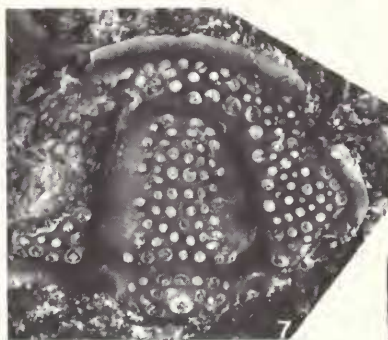
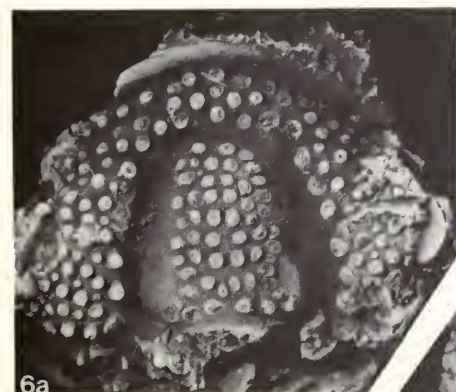
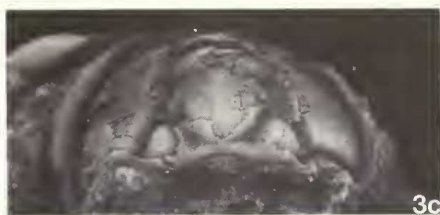
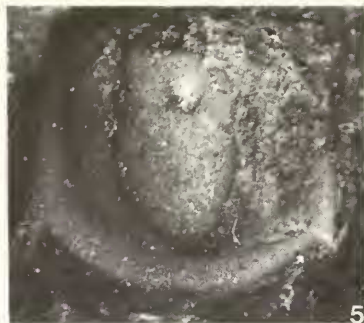


Fig. 2 Two stratigraphic sections, respectively NW and north of Sosink (see Fig. 1, p. 3), showing horizons of fossil localities in the Sosink Formation.

**Figs 3–5** *Peronopsis fallax* (Linnarsson, 1869) aff. *minor* Brögger, 1878. All loc. S.4. Figs 3a–d, anterior, plan, posterior and left lateral views of almost exfoliated cephalon. It.2107,  $\times 9$ . Fig. 4, internal mould of pygidium. It.2108,  $\times 8$ . Fig. 5, almost complete pygidium with exoskeleton intact. It.2110,  $\times 12$ .

**Figs 6–10** *Solenopleuropsis marginata marginata* Sdzuy, 1958. All loc. S.1. Figs 6a, b, plan and oblique left anterolateral views of incomplete cranium. It.1106,  $\times 7$ . Fig. 7, plan view of incomplete cranium; note median occipital tubercle. It.1110,  $\times 6$ . Fig. 8, part of small (meraspid?) cranium. It. 1099,  $\times 16$ . Fig. 9, almost complete cranium showing small, smooth, left palpebral lobe. It. 1119,  $\times 5$ . Fig. 10, oblique left lateral view of cranium. Note transverse arrangement of tubercles on posterior part of glabella, and posteriorly-inclined, spine-like tubercles on occipital ring. It. 1095,  $\times 6$ .





**DIMENSIONS.** Cephalon, It.2107: median length 4.5 mm, overall breadth 5.1 mm, length of axis 3.2 mm, median breadth of axis 1.5 mm. Pygidium, It.2108: overall breadth 5.2 mm\*, length (excluding half-ring) 4.6 mm, length of axis 3.6 mm, frontal breadth of axis 2.9 mm\*.

**DESCRIPTION AND DISCUSSION.** Descriptions and illustrations of *Peronopsis fallax minor* and several other subspecies of *P. fallax* were given by Westergård (1946). Further comments were made by Fortey & Rushton (1976 : 326–327) in discussing Iranian specimens determined by them as *P. fallax* aff. *minor*. Westergård's (1946: pl. 3, figs 5–7) illustrations of the pygidium of *P. fallax minor* demonstrate considerable variation in the form and relative size of the axis, and the present specimens fall within this variation; in particular It.2110 (Fig. 5) agrees closely with an original of Westergård (1946 : pl. 3, fig. 7). Fortey & Rushton (1976 : 326) noted that in *P. fallax minor* the 'pygidial flanks', a term corresponding to 'pleural lobe' of Palmer (1955 : fig. 1) and to 'pleural field' of Harrington, Moore & Stubblefield, in Moore (1959 : O214), are confluent behind the axis. The same feature is found in the present material, though it is less conspicuous on the external surface (Fig. 5) than on an internal mould (Fig. 4), where both border furrow and axial furrows are notably broad.

Comparison of the Turkish cephalon with *P. fallax minor* is more tenuous and a largely exfoliated cephalon now illustrated (Figs 3a–d) shows two distinct pairs of lateral lobes of approximately equal length (exs.) on the posterior glabellar lobe; similar structures are clearly visible on cephalon of *Peronopsis cylindrica* Westergård (1946: pl. 3, figs 17, 19, 20) and *P. quadrata* (Tullberg, 1880) (see Westergård 1946: pl. 3, figs 22, 23, 25, 26, 28) from Sweden. On the other hand the external surface of cephalon from loc. S.4 shows little evidence of furrows on the posterior glabellar lobe, though the pair of glabellar lobes immediately behind the transglabellar furrow is always apparent; similar lobes, involving a slight expansion of the glabellar outline, may be seen, though less well developed, on a cranidium of *P. fallax minor* figured by Westergård (1946: pl. 3, fig. 4). The occipital lobes (Whittington 1963 : 28) are similarly more distinct on the internal mould (Fig. 3b) than on the external surface of cephalon from S.4.

According to Westergård (1946 : 39) *P. fallax minor* occurs in the *Solenopleura brachymetopa* Zone, late Middle Cambrian, of Scandinavia, where its age may not be very different from that of the Sosink specimens. Closely similar material from near Nuneaton, central England, determined first as *P. fallax* cf. *minor* by Taylor & Rushton (1972 : 19; see Fortey & Rushton 1976 : 327; pl. 12, fig. 15) and later as *P. fallax minor* (Rushton 1978 : 251; pl. 24, fig. 1), came from the *Agnostus pisiformis* Zone, earliest Upper Cambrian.

Family **SOLENOPLEURIDAE** Angelin, 1854

Subfamily **SOLENOPLEUROPSINAE** Thoral, 1947

[= *Saoinae* Hupé, 1953].

Genus **SOLENOPLEUROPSIS** Thoral, 1947

**TYPE SPECIES.** By original designation, *Conocoryphe rouayrouxi* Munier-Chalmas & Bergeron, 1889.

*Solenopleuropsis marginata marginata* Sdzuy, 1958

Figs 6a, b, 7–10

1958 *Solenopleuropsis marginata marginata* Sdzuy: 245; pl. 2, fig. 7.

1961 *Solenopleuropsis marginata marginata* Sdzuy; Sdzuy: 364; pl. 27, figs 6–12; pl. 28, figs 1–7; pl. 31, fig. 7; pl. 34, fig. 6; text-fig. 46.

**FIGURED MATERIAL.** It.1095 (Fig. 10), It.1099 (Fig. 8), It.1106 (Figs 6a, b), It.1110 (Fig. 7), It.1119 (Fig. 9).

**HORIZON AND LOCALITY.** The species was found at only one level, 18 m above the base of the Sosink Formation, at loc. S.1, NW of Sosink.

**ADDITIONAL MATERIAL.** Fifteen cranidial fragments from loc. S.1.

| DIMENSIONS (in mm).             | It.1095 | It.1099 | It.1106 | It.1110 | It.1119 |
|---------------------------------|---------|---------|---------|---------|---------|
| Max. breadth of cranidium       | —       | 4·5     | 9·5     | 12·0*   | 11·4    |
| Median length of cranidium      | 7·5     | 3·0     | 6·6     | 7·5     | 7·8     |
| Frontal breadth of cranidium    | 5·1     | 2·1     | 6·0*    | 7·0     | 6·5     |
| Distance across palpebral lobes | 8·8     | —       | 8·6     | 10·1    | 10·1    |
| Basal breadth of glabella       | 3·2     | 1·4*    | 3·2     | 3·9     | 4·3     |

**DESCRIPTION AND DISCUSSION.** The present cranidia, all of which come from a single thin (5 cm) bed of limestone, exhibit some variation in glabellar proportions (possibly the result of compression) and in the number and regularity of the tubercles; they agree well with the holotype and with other specimens from Spain illustrated subsequently by Sdzuy (1961; see synonymy), some of which may have smaller, more numerous tubercles and, occasionally, four subconcentric rows in front of the glabella. Most of the other species described by Sdzuy (1958 : 242–246; 1961 : 354–373) are readily eliminated from present consideration on the basis of subangular outline of anterior border, long (sag.) preglabellar field, lack of glabellar furrows, and the large number of very small tubercles on the cranidium. *Solenopleuropsis* cf. *ribeiroi* (de Verneuil & Barrande, 1860) as figured by Sdzuy (1961 : pl. 26, figs 3–5) apparently has large tubercles like those of Turkish material on the preglabellar field but not on the glabella and posterior portions of the fixigenae, where they are much smaller. *S. ribeiroi* was considered by Sdzuy to be of doubtful validity and was rejected by Courtessole (1973 : 148). The ornamentation of large tubercles found in *Solenopleuropsis thorali* Sdzuy (1958 : 244; 1961 : 365) resembles that of the Turkish specimens but in most cases the preglabellar field has two, rather than three, concentric rows of tubercles, and their arrangement is more regular. A more reliable criterion may be the greater width (tr.) of the frontal area in *S. marginata marginata*.

Cranidia of all the several species of *Solenopleuropsis* described from the Middle Cambrian of the Montagne Noire, SW France (see Courtessole, 1973: 143–159 for review) are ornamented with smaller, more closely crowded tubercles than *S. marginata marginata* or *thorali*. In certain cases (for example, *S. rouayrouxi* (Munier-Chalmas & Bergeron, 1889), redescribed by Courtessole 1973: 148) the number of both tubercles and concentric rows of tubercles on the preglabellar field may vary widely.

Family **CONOCORYPHIDAE** Angelin, 1854

Genus **CONOCORYPHE** Hawle & Corda, 1847

[= *Couloumania* Thoral, 1946].

**TYPE SPECIES.** By subsequent designation of Miller, 1889, *Trilobites sulzeri* Schlotheim, 1823.

Subgenus **CONOCORYPHE** Hawle & Corda, 1847

***Conocoryphe* (*Conocoryphe*) *caecigena* sp. nov.**

Figs 11a, b, 12

**DIAGNOSIS.** *C. (Conocoryphe)* species with parabolic glabellar outline and three unequal pairs of lateral glabellar lobes; 1p and 2p glabellar furrows broad (exs.) and moderately deep, but 3p pair transverse and slit-like. Pair of protuberances, generally resembling eyes in form but lacking visual surfaces and palpebral lobes or furrows, sited opposite 3p glabellar lobes and midway between glabella and lateral border furrow. Surface of exoskeleton, excluding furrows, ornamented with closely-spaced, coarse tubercles.

**HOLOTYPE.** It.1121 (Figs 11a, b). Dimensions: max. breadth of cranidium 16.5 mm, median length of cranidium 8.7 mm, length of glabella and occipital ring 6.1 mm, max. breadth of glabella 5.1 mm.

**OTHER MATERIAL.** It.1124 (Fig. 12), and three unfigured cranidial fragments.

**HORIZONS AND LOCALITIES.** The holotype and the unfigured fragments are from loc. S.5, approx. 95 m above the base of the Sosink Formation at the section NW of Sosink. It.1124 is from loc. S.12, north of Sosink, at a level 115 m above the base of the Sosink Formation.

**DESCRIPTION AND DISCUSSION.** The new form is one of a small number of *C. (Conocoryphe)* species, termed 'oculé' by Courtessole (1976b), in which eyes are apparently represented by a pair of protuberances which lack any trace of visual surface; the animal presumably was blind. The anterior and lateral borders of the cranidium of *C. (C.) caecigena* form a continuous structure which narrows posterolaterally. The almost marginal position of the facial suture, cutting the cephalic border obliquely near the genal angles so that the librigenae must have been diminutive dorsally, matches that illustrated by Šnajdr (1958: fig. 32) for *C. (Conocoryphe) sulzeri* (Schlotheim) and by Sdzuy (1961: figs 48–53) for other members of the Conocoryphidae. There is no sign of a conventional type of facial suture linking the eye-like protuberances with the anterior and posterior borders. As for the protuberances themselves (Fig. 12), the tuberculation of the fixigenae continues onto the nearly horizontal dorsal surface but is then replaced by closely-grouped granules on the laterally-facing, almost vertical sides, which in conventional trilobites would correspond to the visual surfaces. The fixigenae become narrower frontally where they are linked by a narrow (sag.) ridge, surmounted by a single arc of tubercles, that represents the preglabellar field. The coarsely tuberculated surface of the new species, combined with the broad (exs.), smooth areas containing the very shallow lateral glabellar furrows, gives it a characteristically prickly appearance, and many of the tubercles (Fig. 11a) show a small median perforation, suggesting they are bases of broken-off spines.

Other species of *C. (Conocoryphe)* which bear rudimentary, 'eye-like' protuberances generally resembling those of *C. (C.) caecigena* include the following:

*C. (C.) pseudooculata* Miquel, 1905, redescribed by Courtessole (1973 : 188; includes full synonymy). Middle Cambrian (Niveau F), Montagne Noire, SW France.

*C. (C.) palpebralis* Sdzuy (1957 : 21). Middle Cambrian, Doberlug, Germany.

*C. (C.) havliceki* (Šnajdr). Described originally as *Couloumania havliceki* Šnajdr (1957 : 239; 1958 : 172, 251). Middle Cambrian, *Eccaparadoxides pusillus* Zone, near Jince, Bohemia.

*C. (C.) ferralsensis* Courtessole (1967a : 501). Middle Cambrian (Niveau H), Montagne Noire, SW France.

*C. (C.) sdzuyi* Courtessole (1967b : 527). Middle Cambrian, Spain. Based on material previously attributed to *C. (C.) pseudooculata* by Sdzuy (1961 : 664).

According to Courtessole (1973 : 192), *C. (C.) pseudooculata* differs from *C. (C.) ferralsensis* in having more strongly developed protuberances (for which he used also the

**Figs 11–12** *Conocoryphe (Conocoryphe) caecigena* sp. nov. Figs 11a, b, plan and left lateral views of cranidium. **Holotype**, It.1121,  $\times 4.5$ . Loc. S.5. Fig. 12, left anterolateral view of left genal region of cranidium, showing 'ocular' protuberance. Note absence of eye lenses and facial suture. It.1124,  $\times 2.5$ . Loc. S.12.

**Figs 13–18** *Dorypyge terneki* sp. nov. Fig. 13, hypostoma. It.2090,  $\times 6$ . Loc. S.3. Figs 14a, b, anterior and plan views of pygidium showing marginal spines inclined posterolaterally. It.2076,  $\times 4$ . Loc. S.4. Fig. 15, left librigena. It.1138,  $\times 6$ . Loc. S.5. Fig. 16, dorsal view of partly exfoliated cranidium. **Holotype**, It.2080,  $\times 3$ . Loc. S.4. Fig. 17, incomplete pygidium. MTA coll., unnumbered,  $\times 7$ . Loc. S.4. Fig. 18, oblique left lateral view of incomplete cranidium with occipital spine intact. It.2077,  $\times 4$ . Loc. S.4.





11a



11b



12



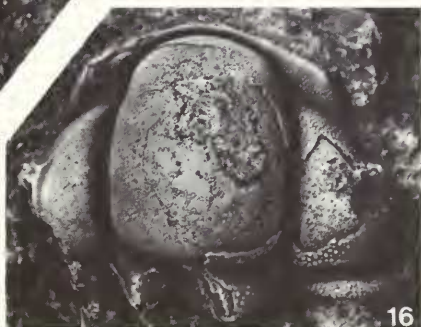
15



13



14a



16



14b



17



18

term 'bosse oculaire'), a shorter, subconical (compared with conico-oval) glabella and a lateral border ornamented with a single row of well-spaced tubercles, compared with two or three rows of closely-spaced tubercles. *C. (C.) caecigena* has coarser ornamentation, with fewer and conspicuously larger tubercles, than either of the two French species, but bears a closer resemblance to *C. (C.) ferralsensis* than to other described species.

*C. (C.) palpebralis* has a subtrapezoidal glabellar outline with poorly-differentiated glabellar lobes; the protuberances are set very close to the glabella, and the surface lacks coarse tubercles.

*C. (C.) havliceki* carries relatively large tubercles, though they are even sparser than in *C. (C.) caecigena*, but the glabellar outline is almost straight-sided, longer and narrower than that of the Turkish species, with poorly-defined glabellar furrows and a conspicuously long preglabellar field. *C. (C.) sdzuyi* is readily distinguished from *C. (C.) caecigena* in having ornamentation comprising smaller tubercles, protuberances which are both smaller and set closer to the glabella and a longer preglabellar field with two or three rows of tubercles.

### *Conocoryphe* (s.l.) sp.

Figs 61–63 (p. 33)

FIGURED SPECIMENS. It.1144 (Figs 62a, b) from loc. S.1; It.1148 (Fig. 61) from loc. S.5; It.3403 (Figs 63a–c) from loc. S.13. The stratigraphic levels are respectively 18 m, 95 m and 135 m above the base of the Sosink Formation.

OTHER MATERIAL. Two fragments of pygidium from loc. S.5.

DESCRIPTION AND DISCUSSION. It.1148 and It.3403 agree essentially with the pygidium of *C. (Conocoryphe) sulzeri* (Schlotheim), from the Middle Cambrian of Bohemia, illustrated by Šnajdr (1958: pl. 33, see esp. figs 8, 9), but have a proportionately larger axis. The number of axial rings (four) and pairs of pleural furrows (four) is the same in both the Turkish and Czech material. Šnajdr's illustrations show the pleural furrows varying from well-defined to almost obsolete, and their degree of definition appears to be of little value as a distinguishing feature. A general comparison may also be made with a pygidium of *C. (Conocoryphe) brevifrons* (Thoral) from SW France illustrated by Courtessole (1973: pl. 19, fig. 7), but no useful comment can be made in the absence of the cephalon. The surface of the exoskeleton of the Sosink material is covered with closely-spaced granules and sparse, low tubercles, a form of ornamentation which suggests that the species may not be *C. (C.) caecigena*, described earlier. On the other hand Šnajdr's (1958: pl. 33, figs 1, 2, 8–10) illustrations of the pygidium of *C. (C.) sulzeri* show a smooth surface, contrasting with the tubercles ornamenting the cephalon. Similar differences in ornamentation between cephalon and pygidium in *C. (Conocoryphe)* are apparent in material from Spain and France illustrated by Sdzuy (1961: pl. 30, fig. 9; pl. 31, fig. 11) and Courtessole (1973: pl. 17, figs 13, 14; pl. 18, fig. 13; pl. 19, figs 7, 14–16).

It.1144 is a very small, probably meraspid, pygidium and shows only two axial rings and two pairs of pleural furrows. The surface is ornamented with closely-spaced granules and the specimen may possibly represent the same species as the pygidia described above.

### Family DORYPYGIDAE Kobayashi, 1935

#### Genus *DORYPYGE* Dames, 1883

TYPE SPECIES. By original designation, *Dorypyge richthofeni* Dames, 1883.

#### *Dorypyge terneki* sp. nov.

Figs 13–18

DIAGNOSIS. *Dorypyge* species with two unequal pairs of poorly-defined lateral glabellar lobes. Glabellar outline constricted anteriorly to form frontal glabellar lobe which extends



beyond sharply-defined border furrow to invade most of anterior border. Occipital ring carries long, backwardly-curved median spine. Pygidium (excluding spines) broader than long; one-third of its breadth occupied by straight-sided axis carrying three distinct, transversely straight axial rings and traces of a fourth. Anterior half ribs and succeeding three pairs of ribs separated by deep pleural furrows and ending in subequal pairs of curved, sharply-pointed, marginal spines; fourth ribs end in a fifth pair of spines, long, stout and recurved, between which a pair of short, pointed projections is sited on posterior margin. Surface of exoskeleton, excluding furrows, ornamented with closely-spaced small tubercles.

HOLOTYPE. It.2080 (Fig. 16).

OTHER MATERIAL. It.1138 (Fig. 15), It.2076 (Figs 14a, b), It.2077 (Fig. 18), It.2090 (Fig. 13), MTA coll. unnumbered (Fig. 17), and 53 unfigured, fragmentary specimens, comprising 20 cranidia, 9 hypostomata, 4 librigenae and 20 pygidia.

HORIZONS AND LOCALITIES. All the available specimens are from levels between 35 m and 115 m above the base of the Sosink Formation, both NW and north of Sosink. It.2090 is from loc. S.3; It.2076, It.2077, It.2080 and MTA coll. unnumbered are from loc. S.4, where the species proved most abundant; It.1138 is from S.5 and rare examples were found at S.2 and S.12.

DIMENSIONS. Cranidium, It.2080: overall median length 13 mm, maximum breadth 18.8 mm\*, length of glabella and occipital ring (excluding spine) 12.6 mm, basal breadth of glabella 7.5 mm, distance across palpebral lobes 14.8 mm. Pygidium, It.2076 (excluding marginal spines): maximum breadth 8.6 mm, median length 7.9 mm, frontal breadth of axis 4.3 mm, length of axis 6.8 mm.

DESCRIPTION. Cranidium, excluding occipital spine, almost one and a half times as broad as long, strongly convex and steeply declined anteriorly. Glabella convex, standing well above adjacent portions of the fixigenae, with median breadth four-fifths the median length (excluding occipital ring). Sides of glabella distally convex, curved; outline parallel-sided posteriorly but narrowing anteriorly to the broadly rounded frontal glabellar lobe, whose breadth is just more than three-quarters that of the glabella. Frontal glabellar lobe is subangular in plan, and immediately behind is a pair of ill-defined indentations which coincide with the narrower outline noted above (Fig. 16). Unequal 1p and 2p lateral glabellar lobes together occupy more than half the length of the glabella; 1p and 2p furrows are scarcely visible and there is a mere trace of a 3p pair. Large occipital ring is produced to form a sharp occipital spine that curves upwards and back. Palpebral lobes are set high on the fixigenae, opposite approximately the hindmost third of the glabella; weak eye ridges die out without reaching the axial furrows. Anterior branches of the facial suture are subparallel as far as the anterior border and then turn adaxially to cut the margin at an obtuse angle; posterior branches curve evenly to the posterior border, which turns forwards abaxially beyond the fulcra. Anterior border is broadest (exs.) and flat abaxially, and set almost at right angles to the convex fixigenae, from which it is separated by a distinct border furrow; adaxially the border diminishes to a narrow rim circumscribing the front of the glabella. A single librigena (Fig. 15) shows the border widening markedly near the genal angle, which is produced to form a stout, incurved, librigenal spine.

The hypostoma (Fig. 13) is typical for the genus, with middle body divided into two lobes, the posterior lobe occupying one-fifth the median length. The more convex anterior lobe carries ornamentation comprising anastomosing ridges and is separated from the low, granulated posterior lobe by a faint middle furrow with a pair of weakly developed maculae. The rim-like border extends laterally to form a pair of subtriangular anterior wings.

The well-segmented pygidium is strongly convex, with axis that stands high above the pleural regions and occupies two-fifths of the breadth and almost all the median length. Straight sides of the axis converge gently to the bluntly rounded tip, and three-fifths of its



length (excluding articulating half-ring) are occupied by three large, subequal, axial rings; the latter are delimited by transversely straight, deep, ring furrows and there is a faint fourth ring furrow. Pleural regions carry five pairs of deep pleural furrows, and the ribs, together with the pair of anterior half-ribs, are produced posterolaterally to form stout, sharply-pointed, backwardly curved marginal spines. Anterolateral margin of the anterior half ribs forms a pair of small, steeply declined facets. First four pairs of marginal spines are almost equisized, followed by a large fifth pair, between which the margin of the postaxial field carries a pair of small, short projections just inside the line of the axial furrows. In anterior view (Fig. 14a) the marginal spines, from first to fifth, are seen to turn progressively more strongly abaxially upwards, apparently corresponding to the resting position of the animal on the sea-floor; one large, possibly gerontic, unfigured pygidium (It. I 139) has the fifth pair of spines recurved adaxially.

**DISCUSSION.** Schrank's (1977 : 145) redescription of *Dorypyge richthofeni* Dames, 1883 from the Middle Cambrian of Wulopu, China, shows that *D. terneki* differs in minor respects, though the two are certainly congeneric. In *D. richthofeni* the posterior three-quarters of the glabella expands forwards, compared with the subparallel outline in *D. terneki*; the anterior border is less inclined frontally and the border furrow is much less distinct. The occipital spine is of similar form and size in both species. The pygidium of *D. richthofeni* is proportionately longer and its larger axis has a longer terminal piece; the first four pairs of marginal spines are straighter, directed posterolaterally instead of curving backwards. The posterior margin between the large fifth spines is blunt in some examples of *D. richthofeni*, but two specimens (Schrank 1977: pl. 2, fig 4) have a pair of distinct, slim spines; none shows short, pointed projections like those of *D. terneki*. Tubercles ornamenting the cranidium of *D. richthofeni* are much coarser than in the Turkish species, but those on the pygidium are similar. Schrank (1977 : 143) proposed a scheme showing changes in the number and disposition of marginal spines on the pygidium of *Dorypyge* throughout the Middle Cambrian; on the basis of this feature, *D. terneki* would be intermediate between *D. aenigma* (Linnarsson, 1869) and *D. richthofeni*, at a level approximating to the highest part of the *Paradoxides paradoxissimus* Stage. The irregular distribution of spines along the margin of *D. aenigma* as shown diagrammatically by Schrank does not correspond with the evenly-spaced spines illustrated by Westergård (1948: pl. 2, figs 8a, b) for the species.

The hypostoma of *D. terneki* (Fig. 13) is proportionately longer, with outline less arched frontally, than that of *D. richthofeni* (see Schrank 1977: pl. 2, fig. 5), and has more pointed anterior wings. In all these features, plus the ornamentation of anastomosing ridges, there is a remarkably strong resemblance to the hypostoma of *Dorypyge aenigma* (Linnarsson, 1869), from the *Solenopleura brachymetopa* Zone, late Middle Cambrian, of Västergötland, Sweden, redescribed by Westergård (1948 : 7; pl. 2, figs 1–8). Pygidia of the two species are closely similar, including the number and form of the axial rings. Differences are minor, but the marginal spines of *D. aenigma* are slimmer and straighter and there is no evidence of a sixth pair immediately behind the axis; Westergård (1948 : 9) considered the large, fifth pair to be the last. The glabella of *D. aenigma* is broader anteriorly than that of *D. terneki*, the constriction of the frontal glabellar lobe is less in evidence, the anterior branches of the facial suture are less convergent anteriorly and the librigenal spines are slimmer. Both species carry similar ornamentation of closely-spaced, small tubercles.

Of the Middle Cambrian species and subspecies of *Dorypyge* from Iran described by Kushan (1973), *D. iranensis iranensis* Kushan (1973 : 136; pl. 26, figs 1–6; text-fig. 9) and *D. iranensis reticulata* Kushan (1973 : 136; pl. 26, figs 7–10) appear most relevant to the present discussion. Both have a glabellar outline that is narrower at the occipital ring and expands forwards, and the anterior margin of the cranidium is more broadly rounded than in the Turkish species. The pygidium of both subspecies carries six pairs of marginal spines, but that of *D. iranensis iranensis* has four well-defined axial rings and smaller, slimmer, first to fourth marginal spines than *D. terneki*, though the sixth spines are slightly longer. The pygidium of *D. iranensis reticulata* is proportionately longer than either of the above, with

only three axial rings, a notably longer terminal piece, and shorter first to fourth marginal spines.

Comparison of *Dorpyge terneki* with deformed examples of *D. asturiana* Sdzuy (1958: 240; pl. 1, figs 6, 7; 1961 : 335; pl. 22, figs 8–16, text-fig. 31), from the middle of the *Solenopleuropsis* horizon in northern Spain, is difficult. Sdzuy's illustrations suggest a glabella which expands anteriorly and lacks a constricted frontal lobe; the pygidium is wider frontally, lacks any trace of sixth marginal spines, and has only three axial rings.

Although Courtessole's (1973) revision of the Middle Cambrian trilobites of the Montagne Noire, SW France, did not list *Dorpyge*, the genus was reported previously from the area, though not described. Thoral (1935 : 61, 70, 76) noted an earlier record by Miquel at Coulouma and listed the genus from the 'Zone à *Conocoryphe Levyi*', said to be in the upper half of the middle Acadian (Acadian = Middle Cambrian).

Family **PARADOXIDIDAE** Hawle & Corda, 1847

Subfamily **PARADOXIDINAE** Hawle & Corda, 1847

Genus **PARADOXIDES** Brongniart, 1822

TYPE SPECIES. By subsequent designation of Barrande, 1852, *Entomostracites paradoxissimus* Wahlenberg, 1821.

Subgenus **ECCAPARADOXIDES** Šnajdr, 1957

TYPE SPECIES. By original designation, *Paradoxides pusillus* Barrande, 1846.

The classification of *Paradoxides* and allied trilobites is confused and in need of revision. Westergård (1953 : 34; pl. 8, fig. 2) noted and illustrated the type specimen of *P. paradoxissimus* but did not undertake a review of the genus. Šnajdr (1957, 1958) maintained the generic status of *Hydrocephalus* Barrande, 1846 and introduced the three new genera *Eccaparadoxides*, *Acadoparadoxides* and *Luhops*, all founded on type species from the Middle Cambrian of Bohemia, which received only brief mention in the Treatise on Invertebrate Paleontology (Poulsen in Moore 1959 : O213). *Hydrocephalus* was listed by Poulsen as a junior subjective synonym of *Paradoxides*. Sdzuy's (1961: 317–334) account of Middle Cambrian trilobites from northern Spain recognized only *Paradoxides*, but Courtessole (1973 : 123) preferred to regard *Acadoparadoxides* and *Eccaparadoxides* as subgenera of *Paradoxides* in describing Middle Cambrian faunas from the Montagne Noire, SW France. Dr A. W. A. Rushton (personal communication, 1980) has drawn my attention to the fact that *Phanoptes pulcher* Hawle & Corda (1847 : 17; pl. 2, fig. 2), the type species by monotypy of *Phanoptes* Hawle & Corda (1847 : 16), was placed by Šnajdr (1958 : 116; pl. 20, fig. 7) in subjective synonymy with *Eccaparadoxides pusillus*. By implication *Phanoptes* should therefore have priority over *Eccaparadoxides*. *Phanoptes pulcher* was founded on a meraspid, said in the original description to be 1 mm long, from Skryje, Bohemia, and *Phanoptes* has not passed into general use, being placed in synonymy with *Paradoxides* by Poulsen (in Moore 1959: O213). Šnajdr did not press the point and I propose to follow him in using *Eccaparadoxides*, though as a subgenus of *Paradoxides*, to accommodate most of the Sosink Formation's paradoxidids. The Turkish material adds little to our knowledge of *Acadoparadoxides*; pygidia from the higher part of the fossiliferous section at Sosink have some features in common with that of the type species, but differ in other respects and so are assigned to *Paradoxides* (s.l.).

***Paradoxides (Eccaparadoxides) remus* sp. nov.**

Figs 19–24, 27–32

DIAGNOSIS. Characteristics of cephalon typical for subgenus but surface of glabella in small cranidia is granulate; that of large specimens carries low tubercles, especially on frontal lobe.

Surface of fixigenae and of pygidium lacks ornamentation. Pygidium typically three-fifths as broad as long, with greatest breadth just behind centre, where confluent anterior and lateral margins form continuous curve or very slight angulation in outline. Low axis, *c.* two-fifths overall length, is subtriangular in outline; poorly defined tip grades into faint postaxial ridge that traverses most of otherwise dorsally concave surface of confluent unfurrowed pleural regions. Axis shows faint traces of two axial rings. Tip of pygidium forms pair of short points, separated by narrow (tr.), curved notch.

HOLOTYPE. It.2166 (Fig. 32).

OTHER MATERIAL. It.1089 (Fig. 22), It.1092 (Fig. 21), It.1093 (Fig. 19), It.2201 (Fig. 20), It.2161 (Fig. 23), It.2169 (Fig. 31), It.2218 (Fig. 24), It.2226 (Fig. 28), It.2229 (Fig. 29), It.2238 (Fig. 27) and It.2239 (Figs 30a, b). Also 74 other unfigured, mostly fragmentary specimens, distributed as follows: 16 (two of them pygidia) from S.3, 9 (two pygidia) from S.4, 3 (two pygidia) from S.5, 18 (three pygidia) from S.11, 16 (three pygidia) from S.12 and 12 (one pygidium) from S.13.

LOCALITIES AND HORIZONS. Locs S.3, S.4, S.5, S.11, S.12 and S.13; these range from 53 m to 135 m above the base of the Sosink Formation. *P. (E.) cf. remus* (see p. 19) was found at S.2, 35 m above the base of the formation.

| DIMENSIONS (in mm). Cranidia                 | It.1092 | It.2218 | It.2226 | It.2229 | It.2239 |
|----------------------------------------------|---------|---------|---------|---------|---------|
| Median length of cranidium                   | 20·6    | 6·6     | 2·5     | 3·4     | 20·5*   |
| Median length of glabella and occipital ring | 19·2    | 5·8     | 2·2     | 2·9*    | 18·9    |
| Max. breadth of glabella                     | 12·6    | 3·6     | 1·2     | 1·8     | 12·7    |
| Breadth (tr.) of occipital ring              | 9·4     | 2·9     | 1·0*    | 1·2*    | 9·5     |
| Max. breadth (tr.) of frontal area           | —       | 7·3*    | 2·9     | 3·9*    | —       |
| Distance across palpebral lobes              | 22·2    | 7·5*    | 2·9     | 3·9*    | 21·6*   |

Dimensions of holotype pygidium: median length, excluding articulating half-ring and marginal spines, 7·8 mm, maximum breadth 5·9 mm, median length of axis 3·6 mm, frontal breadth of axis 3·9 mm.

DESCRIPTION AND DISCUSSION. Šnajdr's (1957 : 238; 1958 : 114, 248) accounts of the characteristic features of *Eccaparadoxides* may be summarized (with appropriate modifications of terminology) as follows: glabellar outline pear-shaped, with four pairs of lateral furrows, the 1p and 2p pairs transglabellar; no preglabellar field present on large cranidia, though well developed on meraspid; palpebral lobes abaxially convex in plan, very long, and extending from near axial furrows almost to posterior border furrow; posterior branches of facial suture very short; pygidial outline elongate, subhexagonal, with short (less than half overall length of pygidium), triangular axis, wide doublure, and a posterior margin which may be concave or carry one or two pairs of marginal spines.

The new species clearly fulfils the requirements of *P. (Eccaparadoxides)* and shares all the above features with the type species *P. (E.) pusillus* Barrande, 1846 from Skryje, Bohemia, redescribed by Šnajdr (1957 : 238; 1958: 116, 248). Large cranidia figured by Šnajdr are slightly deformed but have deeper palpebral furrows and 3p and 4p glabellar furrows; the anterior branches of the facial suture are less divergent forwards, and the lateral extensions of the frontal area are shorter (tr.) (compare Fig. 27 with Šnajdr 1958 : pl. 21, figs 6, 11). Similar criteria apply to small cranidia of both species, in which the preglabellar field is relatively long (sag.), with the additional difference that the 2p transglabellar furrow is conspicuously deeper in *P. (E.) pusillus*.

During ontogeny of *P. (E.) remus* the mesial longitudinal ridge in front of the glabella disappeared, the preglabellar field became progressively reduced so that glabella and anterior border were eventually separated by a single furrow, palpebral furrows became



weaker and are virtually absent from largest examples, and the 3p and 4p glabellar furrows deepened while the 2p transglabellar furrow became both shallower and more sinuous medially. Small cranidia (Figs 22, 24) show the surface of the glabella (but not fixigenae) granulate; large examples have numerous low tubercles, particularly on the frontal lobe where some tubercles show traces of a median perforation. In his account of *P. (E.) granulosis* from SW France, Courtessole (1973 : 131; pl. 8, figs 4, 5) emphasized the importance of the granulose surface, which he had observed elsewhere only in *Paradoxides forchhammeri* Angelin, 1854, a species with small eyes and short pygidium assigned by Bergström & Levi-Setti (1978) to *Paradoxides sensu stricto*. On the other hand Lake (1935: 205) showed that tuberculation is present, though not always preserved, on the exoskeleton of *Paradoxides davidis* Salter, 1863, from the Middle Cambrian of south Wales; the feature may be more common than has been appreciated.

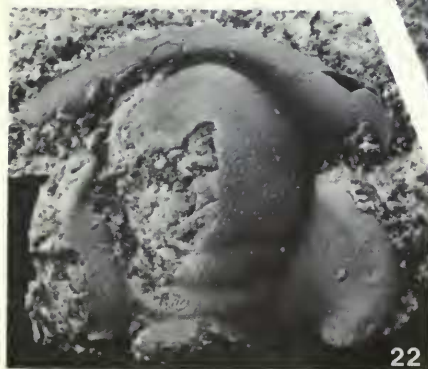
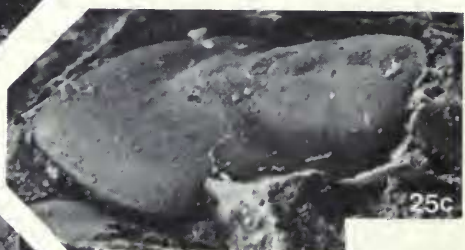
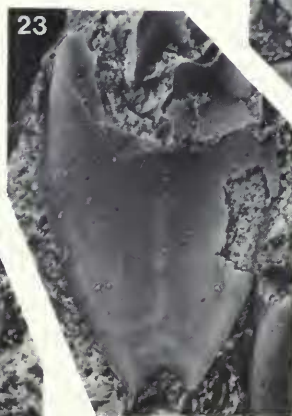
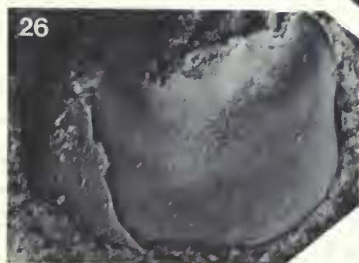
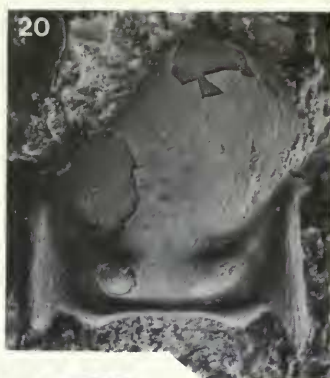
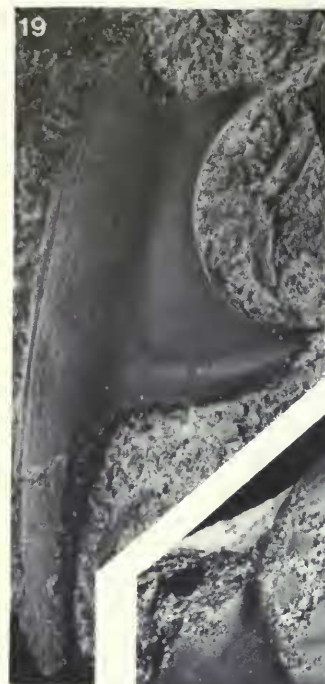
Librigenae (Fig. 19) are typical for the genus but emphasize the diminutive posterior branch of the facial suture and the transverse direction of the anterior branch on to the border, where it curves sharply forwards through a right-angle to cut the margin.

The hypostoma of *P. (Eccaparadoxides)* is a relatively conservative structure and apparently of limited use in differentiating species. It.2201 (Fig. 20) is closely similar to the hypostoma of *P. (E.) pusillus* illustrated by Šnajdr (1958 : pl. 21, figs 8, 9, 17, 18); minor differences include the longer posterior lobe and spines, and the longer, almost parallel-sided posterior portions of the lateral border in *P. (E.) remus*.

Essentially similar hypostomata from France were figured by Courtessole (1973: pl. 7, fig. 4; pl. 9, fig. 8) for *P. (E.) brachyrachis* Linnarsson, 1883 and *P. (E.) macrocerus* Courtessole, 1967 but detailed comparison of such deformed material is difficult. Hypostomata of *P. (E.) pradoanus* de Verneuil & Barrande, 1860 (Sdzuy 1961 : pl. 20, figs 10–14) from northern Spain similarly are not readily distinguished from those of the French species or that of *P. (E.) remus*; apparent differences include the proportionately longer lateral border and longer posterior spines of the Turkish species, criteria difficult to assess when mechanically deformed.

Fragmentary thoracic segments (Fig. 31) are typical for the genus and may carry, in addition to the usual subparallel terrace lines, tubercles similar to those on the glabella.

In discussing pygidia of *P. (Eccaparadoxides)* from the Montagne Noire, SW France, Courtessole (1973 : 123) observed that Šnajdr's criterion of a generally hexagonal outline applied only to *P. (E.) rouvillei* Miquel, 1905 and *P. (E.) mediterraneus* Pompeckj, 1901; on the other hand he considered pygidia of *P. (E.) brachyrachis* Linnarsson, 1883, *P. (E.) melaguensis* Thorval, 1935 and *P. (E.) macrocerus* (Courtessole, 1967) to have a different, non-hexagonal outline, expanded laterally, constricted posteriorly and ending in a pair of strong spines. Alternatively one may regard all the above, together with *P. (E.) pusillus* Barrande, 1846 and *P. (E.) pradoanus* de Verneuil & Barrande, 1860 (see p. 19) as having pygidia of a basically hexagonal, often elongated outline, the postaxial portion of which occupies from about 45% to more than 80% of the median length; the long spines of *P. (E.) brachyrachis* and *P. (E.) macrocerus* do not change this basic concept. The paddle-like pygidium of *P. (E.) remus*, with its median length 1.5–1.7 times the maximum breadth, appears to belong to the same group of species. The pygidium of *P. (E.) pusillus*, redescribed by Šnajdr (1958 : 116), has a much narrower axis than that of *P. (E.) remus*; the pleural regions are wider and the paired terminal spines are set farther apart, though the median notch separating them is shallow and broadly rounded. Following Courtessole's (1973 : 122 *et seqq.*) revision, *P. (E.) remus* differs from other species as follows: the pygidial outline is narrower, the axis longer, and the terminal piece shorter than in either *brachyrachis* or *melaguensis*; the postaxial length is conspicuously less than in *macrocerus*, in which species the outline narrows and then expands to the longer terminal spines; the postaxial length is greater than in *mediterraneus* or *rouvillei*, both of which have the posterior margin either transversely truncate or slightly convex.





*Paradoxides (Eccaparadoxides) cf. remus* Dean, herein  
Figs 33–35

FIGURED MATERIAL. It.2153 (Fig. 35), It.2154 (Fig. 34), It.2190 (Fig. 33).

HORIZON AND LOCALITY. 35 m above the base of the Sosink Formation, at loc. S.2.

DIMENSIONS. Pygidium, It.2154: median length, excluding articulating half-ring and marginal spines, 9.6 mm, maximum breadth 7.1 mm, median length of axis 4.0 mm, frontal breadth of axis 4.2 mm\*.

DESCRIPTION AND DISCUSSION. It.2154 (Fig. 34), with bifid posterior margin, generally resembles the pygidium of *P. (E.) remus* but is proportionately broader, with shorter axis. The specimen occurs stratigraphically below the first undoubted *P. (E.) remus* and bears a stronger resemblance to that species than to the still older *P. (E.) cf. pradoanus* (below). An associated left librigena (Fig. 33) is indistinguishable from that of *P. (E.) remus*, and an incomplete pygidium (Fig. 35) is unusual in that the tip forms a single, blunt point.

The pygidium of the trilobite described by Cobbold (1911 : 286; pl. 24, figs 14–16) as '*Paradoxides rugulosus* Corda' (a species put in the synonymy of *Eccaparadoxides pusillus* by Šnajdr, 1958 : 116) from the Middle Cambrian of Comley, Shropshire, has a bifid tip like that of *P. (E.) remus* but is proportionately wider, with a longer axis and well-developed, convex pleural fields.

*Paradoxides (Eccaparadoxides) cf. pradoanus* de Verneuil & Barrande, 1860  
Fig. 36

cf. 1860 *Paradoxides pradoanus* de Verneuil & Barrande: 526; pl. 6, figs 4–6 only (*vide* Sdzuy, 1961: 322).

cf. 1961 *Paradoxides pradoanus* de Verneuil & Barrande; Sdzuy: 322; pl. 17, figs 15, 16; pl. 18, figs 1–28; pl. 19, figs 1–18; pl. 21, fig. 13; pl. 28, fig. 15; pl. 29, fig. 2; pl. 34, fig. 1; text-fig. 26. Includes synonymy.

FIGURED SPECIMEN. It.1077, from loc. S.1, 18 m above the base of the Sosink Formation.

OTHER MATERIAL. Unfigured pygidium It.1075, from S.1. Ten fragments of cranidia, librigenae and thoracic segments, also from S.1, may belong here but are insufficient for specific determination.

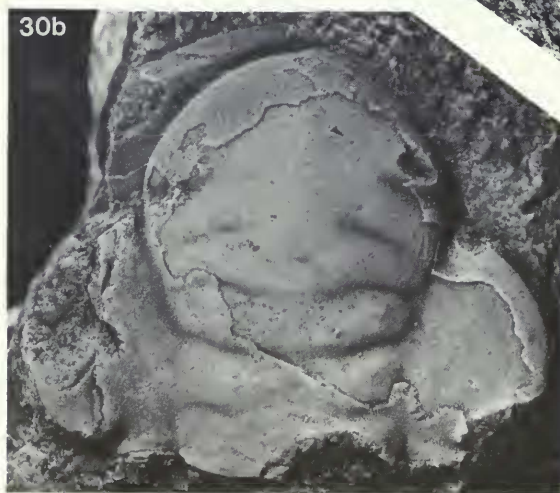
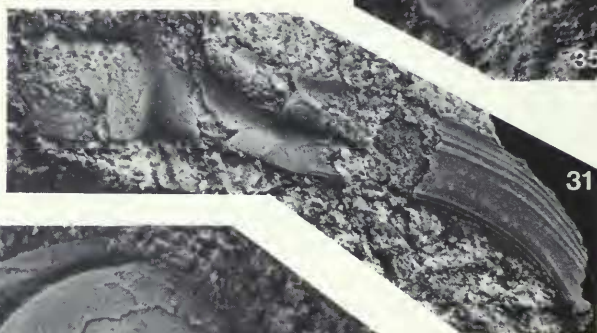
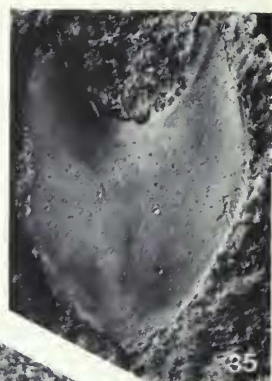
DESCRIPTION AND DISCUSSION. The two available pygidia agree well with Sdzuy's illustrations of the species, based on material from northern Spain. The axis, excluding articulating half-ring, is triangular in outline with one weakly developed axial ring, and that of It.1007 shows traces of low tubercles. The length of the axis is no more than 27% and 29% of the overall length in It.1075 and It.1077 respectively, and may have been less as both

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**Figs 19–24** *Paradoxides (Eccaparadoxides) remus* sp. nov. Fig. 19, latex cast of left librigena with well-developed terrace lines along margin. It.1093,  $\times 2.5$ . Loc. S.12. Fig. 20, almost complete hypostoma. It.2201,  $\times 3$ . Loc. S.4. Fig. 21, large cranidium with well-developed granular ornamentation on anterior half of glabella. It.1092,  $\times 3$ . Loc. S.12. Fig. 22, incomplete small cranidium with granulate glabellar surface. It.1089,  $\times 4.5$ . Loc. S.12. Fig. 23, incomplete pygidium with bifid termination and faint postaxial ridge. It.2161,  $\times 5$ . Loc. S.4. Fig. 24, small cranidium with granules particularly well developed on surface of occipital ring and 1p and 2p glabellar lobes. It.2218,  $\times 7$ . Loc. S.4. See also Figs 27–32.

**Figs 25–26** *Paradoxides (s.l.) pentagonalis* sp. nov. Loc. S.7. Figs 25 a–c, dorsal, posterior, and oblique right lateral views of latex cast of pygidium. Note three shallow depressions, along axial line, which represent position of articulating and ring furrows. **Holotype**, It.2158,  $\times 8$ . Fig. 26, incomplete exfoliated pygidium, questionably referred to the species, in which both posterior and lateral margins are almost straight. The low ridge bounding the axis resembles that seen on the holotype. It.2159,  $\times 6$ .





pygidia have the tip broken off. The axis is not only considerably shorter and more strongly tapered than that of *P. (E.) remus*, but also proportionately narrower frontally (equal to about 50% of the maximum pygidial breadth compared with 70%). Broad, shallow axial furrows become obsolete near the tip of the axis, the terminal piece of which merges with the conjoined pleural regions. Axis extends about halfway to the point of maximum breadth of the pygidium, which marks the posterior limit of a pair of weakly-developed, downturned flanges that represent facets. Behind the point of maximum breadth the pygidial outline narrows only a little less markedly than in *P. (E.) pradoanus* as figured by Szdzy (1958 : pl. 19, figs 14–18).

*Paradoxides* (s.l.) *pentagonalis* sp. nov.

Figs 25a–c, ? 26

**DIAGNOSIS.** Pygidium approximately as broad as long, with subpentagonal outline; subparallel sides represent facets. Pygidial tip usually bluntly pointed but may be subrounded. Axis subtriangular, circumscribed by shallow axial furrows which deepen anterolaterally; pleural fields represented by low, continuous ridge which is widest (sag.) medially and merges with terminal piece of axis, but diminishes anterolaterally. Border wide, gently declined. Position of articulating furrow and one or two ring furrows suggested by very shallow, median depressions. Surface finely granulate when viewed under high magnification.

**HOLOTYPE.** It.2158 (Figs 25a–c).

**OTHER MATERIAL.** It.2163, It.2165, and incomplete cranidia It.2157 and It.2162. It.2159 (Fig. 26) is referred questionably to the species.

**LOCALITY AND HORIZON.** All the specimens are from a weathered 5 cm bed of glauconitic calcarenite at loc. S.7, NW of Sosink; the stratigraphic level is 135 m above the base of the Sosink Formation.

| DIMENSIONS (in mm).                                | It.2148 | It.2158 | It.2163 | It.2165 |
|----------------------------------------------------|---------|---------|---------|---------|
| Median length of pygidium<br>(excluding half-ring) | 5.3     | 6.4     | 6.3*    | 6.5     |
| Maximum breadth                                    | 5.1     | 6.4     | 6.9     | 6.1     |
| Length of axis                                     | 2.8     | 3.2     | 2.9     | 3.2     |
| Frontal breadth of axis                            | 3.4     | 4.0     | 4.6     | 4.0     |

**Figs 27–32** *Paradoxides* (*Eccaparadoxides*) *remus* sp. nov. Fig. 27, fragmentary left half of cranium showing anterior branch of facial suture and four pairs of lateral glabellar furrows. It.2238,  $\times 3.5$ . Loc. S.3. Fig. 28, latex cast of meraspid cranium with preglabellar field and median ridge. It.2226,  $\times 12$ . Loc. S.3. Fig. 29, incomplete small (meraspid ?) cranium. It.2229,  $\times 10$ . Loc. S.11. Figs 30a, b, right lateral and dorsal views of incomplete large cranium. It.2239,  $\times 3$ . Loc. S.3. Fig. 31, part of thoracic segment, with ornamentation comprising tubercles and terrace lines. It.2169,  $\times 3.5$ . Loc. S.3. Fig. 32, pygidium showing concave dorsal surface of confluent pleural regions, faint postaxial ridge and notched posterior margin with pair of terminal points. **Holotype**, It.2166,  $\times 5$ . Loc. S.11. See also Figs 19–24.

**Figs 33–35** *Paradoxides* (*Eccaparadoxides*) cf. *remus* Dean, herein. Loc. S.2. Fig. 33, left librigena. It.2190,  $\times 2.5$ . Fig. 34, latex cast of pygidium. It.2154,  $\times 5$ . Fig. 35, incomplete pygidium with single terminal point in place of the more usual two. It.2153,  $\times 4$ .

**Fig. 36** *Paradoxides* (*Eccaparadoxides*) cf. *pradoanus* de Verneuil & Barrande, 1860. Loc. S.1. Incomplete pygidium with very small axis; line of maximum breadth set relatively far forwards. It.1077,  $\times 4$ .



**DESCRIPTION AND DISCUSSION.** The species is known with confidence only from the pygidium, though undetermined fragments of a cranidium, hypostoma, librigena and thoracic segments of *Paradoxides* (s.l.) were found at the type locality. The weak development of median depressions is unusual, and more clearly visible on the internal mould than on the external surface. The apparent lateral margins of the pentagonal outline correspond to the articulating facets; the low ridge, weakest anterolaterally and broadest (sag.) behind the axis, represents the pleural fields and marks the inner margin of the doublure (seen on unfigured paratype It.2163). A generally similar ridge is visible on pygidia of *Acadoparadoxides sacheri* (Barrande, 1852), type species of the genus, illustrated by Šnajdr (1958 : pl. 16, figs 6, 8–14, 16, 17) but the facets of the Bohemian species are more divergent posteriorly, the first ring furrow is deeper, and the combined axis and pleural fields are proportionately longer. Similar criteria apply to pygidia of the Spanish species *Paradoxides mureroensis* Sdzuy (1958 : pl. 1, fig. 13 only; 1961 : pl. 17, figs 1–5) and *Paradoxides* sp. II of Courtessole (1973 : pl. 10, fig. 2) from SW France. Although Šnajdr (1958 : 250) emphasized the long pygidial axis of *Acadoparadoxides* as being distinct from that of *Eccaparadoxides*, some of his illustrations (Šnajdr 1958 : pl. 16, figs 8, 13, 17) of *A. sacheri* show the axis no longer than that of the Turkish material; in others (Šnajdr 1958 : pl. 16, figs 6, 9, 10, 12) the 'axis' apparently combines both axis and pleural fields. The new species is more closely related to *Acadoparadoxides* than to *Paradoxides* (s.s.), and the proportionately longer pygidium of *P. paradoxissimus* (Wahlenberg, 1821) (Westergård 1953 : pl. 8, fig. 2) has the well-segmented axis clearly separate from almost flat pleural regions.

No intermediate forms have been found linking the type and other pygidia with It.2159 (Fig. 26), referred questionably to *P.* (s.l.) *pentagonalis*, in which the tip is squarely truncated. Pygidia from Comley, Shropshire, illustrated by Cobbold (1911: pl. 24, figs 6, 7) also have the tip square in outline but are otherwise quite different.

#### ? Family **ORDOSIIDAE** Lu, 1954

##### Genus **CHELIDONOCEPHALUS** King, 1937

**TYPE SPECIES.** By original designation, *C. alifrons* King, 1937.

The resemblance of the frontal area of the cranidium of *Chelidonocephalus* to that of *Poshania* Chang, noted by Chang (1959 : 223) and, more particularly, by Fortey & Rushton (1976 : 335), forms the basis of the present discussion. *Poshania* as first used by Chang (1957 : 15, 19–21, 29, 31; pl. 1, fig. 4) was invalid because no generic diagnosis was given; *Poshania poshanensis*, from the Middle Cambrian of Shantung, which was illustrated by means of a line drawing, was apparently the type species by monotypy but not diagnosed or described. Subsequently the genus was both diagnosed and described, with *P. poshanensis* as type species, by Chang (1959 : 200–203, 221–223; pl. 2, figs 4–10; text-fig. 21); he considered *Poshania*, *Namanoia* Lermontova, 1951, *Ordosia* Lu, 1954 and *Taitzuia* Resser & Endo, 1935 to belong to the same family, for which he suggested *Namanoiidae* Lermontova, 1951. Fortey & Rushton (1976 : 335), in seeking an appropriate family for *Chelidonocephalus*, considered both *Namanoiidae* and the superfamily *Rhyssometopacea* Öpik (1967 : 272) ineligible. In the meantime Chang (1963 : 475) assigned *Poshania*, *Ordosia*, *Taitzuia*, *Parataitzuia* Chang, 1963, *Tylotaitzuia* Chang, 1963, *Inouyella* Resser & Endo, 1937 and *Peichiashania* Chang, 1959 to the Subfamily *Ordosiinae* of the Family *Ordosiidae*, a group proposed originally by Lu (1954 : 435) as a monogeneric subfamily of the Family *Leiostegiidae* Bradley, 1925. The same classification was followed by Lu *et al.* (1965 : 219 *et seqq.*).

The type species of *Ordosia*, *O. fimbriicauda* Lu (1954 : 422, 436; pl. 1, figs 12–18; see also Lu *et al.* 1965 : 220; pl. 38, figs 8, 9), from the Kushan Formation of Manchuria and Inner Mongolia, was founded in part on incomplete cranidia with subparallel glabellar outline, a very short (sag.) anterior border, and a poorly-defined area in front of the glabella which may indicate the presence of a plectrum. Based on an incomplete cranidium refigured by Lu *et al.*



(1965 : 221; pl. 38, fig. 10), the type of species of *Taitzuia*, *T. insueta* Resser & Endo in Kobayashi, 1935, is seen to have very wide fixigenae (c. two-thirds the adjacent width of the glabella) and the anterior border close to the frontal lobe, with no indication of a plectrum. Other species of *Taitzuia* have been described and of these *T. glabella* Endo, 1944 and *T. lui* Chu, 1960 (see Lu *et al.* 1965 : pl. 38, figs 14–19) have a glabellar outline and eye ridges like *Chelidonocephalus* and *Derikaspis*, and possibly a median plectrum, though this is less clear. *Poshania poshanensis* and *P. transversa* Chang (1959 : pl. 2, figs 11, 12), though resembling *Chelidonocephalus* and *Derikaspis* in glabellar outline and in the development of eye ridges, plectrum and true border furrow, differ in having a much shorter (sag.) anterior border and no false border furrow. On the other hand *Poshania liaotungensis* (Endo, 1944), *P. obscura* (Walcott, 1905) and *P. tungshanensis* Chang in Lu *et al.* 1965 (see Lu *et al.* 1965: pl. 39, figs 12–14, 17, 18) have a longer anterior border than *P. poshanensis*, and probably also a plectrum and traces of a false border furrow. According to Lu *et al.* (1979 : 30), *Poshania* occurs only in the *Taitzuia* Zone, immediately below the *Damesella* Zone, highest subdivision of the Middle Cambrian in China.

The relationship of *Chelidonocephalus* and *Derikaspis* to *Poshania* appears acceptable, but that to *Ordosia* and *Taitzuia* is less obvious and for the present they are referred only questionably to the Ordosiidae. The Family Tengfengiidae Chang, 1963, founded on *Tengfengia latilimbata* Hsiang, 1962 (Lu *et al.* 1965 : 148; pl. 24, figs 9, 10; misspelt as *Tenfengia latilimbata* on p. 763 – see also *T. cf. latilimbata* of Chang, 1963: pl. 1, fig 8) is considered inappropriate as there are four pairs of glabellar furrows, the glabellar outline expands in front of the 3p glabellar lobes, the preglabellar field is very wide (exsag.), equal to about half the glabellar length, and there is no clear evidence of a plectrum.

***Chelidonocephalus anatolicus* sp. nov.**

Figs 37–42, ?Figs 45–49

**DIAGNOSIS.** *Chelidonocephalus* species with broad (sag.) to very broad, flat anterior border and smooth exoskeletal surface. Anterior border furrow incised distally but shallowing rapidly, becoming indiscernible medially, immediately in front of narrow (sag.), subelliptical plectrum. Pair of elongated (tr.) anterior pits sited in preglabellar furrow, near anterolateral angles of frontal glabellar lobe which may show incipient bilobation. Glabella trapezoidal in outline; in some instances a low median ridge and traces of two or three pairs of lateral glabellar furrows may be present, those of the 1p pair being bifurcate. Palpebral lobes set moderately close to glabella and a short distance in front of posterior border. Low but distinct eye ridges traverse axial furrows to join sides of frontal glabellar lobe. Well-developed occipital ring has median tubercle set well back. Lateral and posterior border furrows join to form single, shallow furrow which extends along stout, moderately long librigenal spine.

**HOLOTYPE.** It.3372 (Figs 37a–c).

**OTHER MATERIAL.** It.3374 (Fig. 42), It.3388 (Figs 39a, b), It.3389 (Fig. 40), It.3407 (Fig. 41), MTA coll. unnumbered (Fig. 38); also 39 mostly fragmentary specimens (32 of them small cranidia) from S.4; 34 (23 of them cranidia) from S.7; 7 from S.8; 5 from S.9; and 4 from S.11. Two hypostomata, It.3390 (Fig. 46) and It.3409 (Figs 47a, b) from loc. S.7 are assigned questionably to *C. anatolicus*. For an account of the pygidia, see discussion of *Derikaspis toluni*.

**LOCALITIES AND HORIZONS.** The holotype is from loc. S.4, and the other specimens are from locs S.7–S.9 and S.11. These localities lie from 80 m to about 182 m above the base of the Sosink Formation.

| DIMENSIONS (in mm).             | It.3372 | It.3388 | It.3389 | MTA Coll. |
|---------------------------------|---------|---------|---------|-----------|
| Median length of cranium        | 8.4     | 10.2    | 4.7     | 9.9       |
| Basal breadth of cranium        | 11.3*   | 14.0*   | —       | 14.2*     |
| Median length of glabella       |         |         |         |           |
| and occipital ring              | 5.5     | 6.4     | 3.2     | 6.6       |
| Basal breadth of glabella       | 3.7     | 5.1     | 2.4     | 4.8       |
| Breadth of frontal area         | 7.7     | —       | 4.2     | 9.0       |
| Distance across palpebral lobes | 8.8*    | —       | 5.4*    | 10.6      |

**DESCRIPTION AND DISCUSSION.** The type and one other species of *Chelidonocephalus* from Iran were described by Fortey & Rushton (1976: 336), whose material has much in common with the new Turkish species; it is preferred to indicate the salient features of the latter rather than give a largely repetitive description. The most conspicuous feature of the cranium of *C. anatolicus* is the large, brim-like structure formed mainly by the very long (sag.) anterior border, which carries a broad (sag.), shallow and often ill-defined false border furrow. The incised anterior border furrow runs from the sides of the cranium in a broad arc, but its median half is either effaced or indicated by a subtle change in slope, immediately behind which is the median plectrum. The latter forms a narrow (sag.), subelliptical strip which may be clearly visible (Fig. 39b), though never strongly defined, but which may be almost indistinguishable (Fig. 38). A small, immature cranium (Fig. 40) has three distinct pairs of lateral glabellar lobes, the false border furrow is relatively deep, the anterior border is short and the abaxial portions of the border furrow are distinct. In the largest cranium (Fig. 42) the anterior border is remarkably long and of scoop-like form owing to widening (sag.) of the false border furrow; the anterior border furrow is shallow, broad (exs.), and dies out adaxially, being replaced by a low ridge that bounds the front of the plectrum. All available cranidia, large and small, have low eye ridges which traverse the axial furrows and join the frontal glabellar lobe, where bilobation of an apparent parafrontal band is weakly developed (Figs 37a, 37c, 38, 39b) in line with an indistinct axial ridge. On the adaxial side of each anterolateral angle of the glabella, one of a pair of elongated depressions occurs in the preglabellar furrow. The depressions appear to correspond to anterior pits (or fossulae; Harrington, Moore & Stubblefield in Moore, 1959: O46, O120), but are sited farther forwards on the glabella and behind the lateral extremities of the plectrum. The surface of the exoskeleton is often smooth, or almost so, particularly in the case of larger specimens; fine granulation may be developed, particularly on the glabella, excluding the weakly-developed two or three pairs of glabellar furrows, which are not incised.

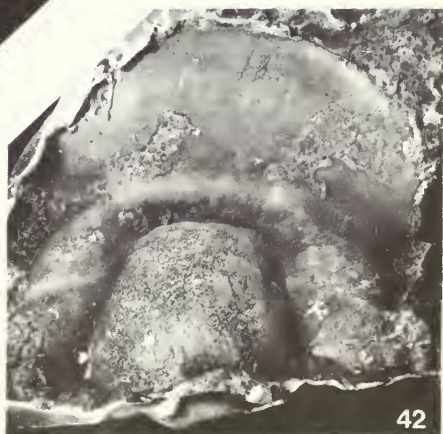
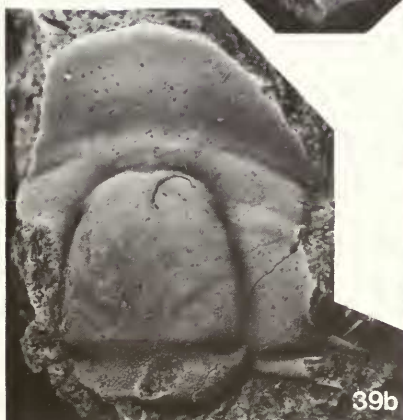
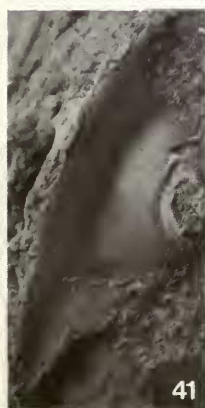
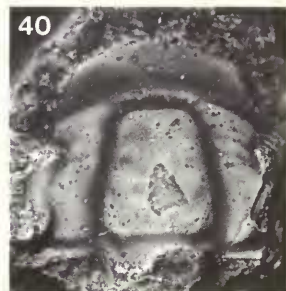
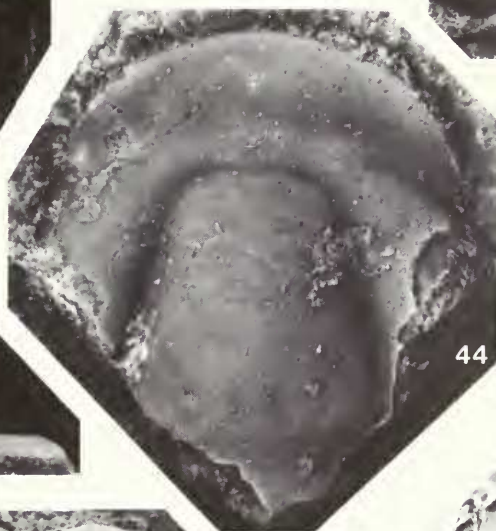
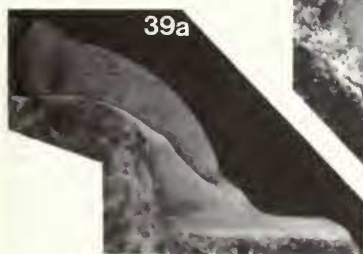
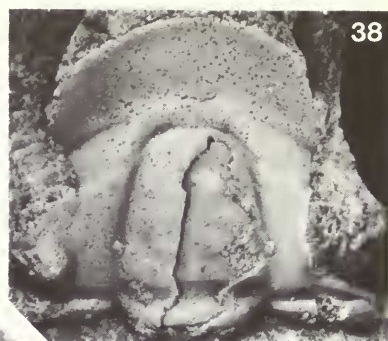
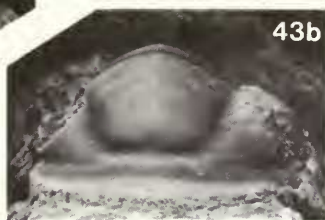
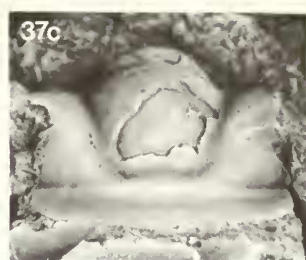
The similarity of *Chelidonocephalus anatolicus* to the Iranian *C. alifrons* King (1937: 17; pl. 2, figs 8a–d), redescribed by Fortey & Rushton (1976: 336), and *C. preannulatus* Fortey & Rushton (1976: 338) is evident. The cranium of *C. alifrons* may be distinguished from

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**Figs 37–42** *Chelidonocephalus anatolicus* sp. nov. Figs 37a–c, dorsal, oblique left lateral and anterior views of almost complete cranium. **Holotype**, It.3372, ×5. Loc. S.4. Fig. 38, incomplete cranium showing outline of palpebral lobe. MTA coll., unnumbered, ×4. Loc. S.7. Figs 39a, b, right lateral and dorsal views of incomplete large cranium showing parafrontal band and very long anterior border. It.3388, ×5. Loc. S.4. Fig. 40, small cranium with relatively long (sag.) palpebral lobes. Three pairs of lateral glabellar furrows are visible, those of the 1p pair bifurcating adaxially. It.3389, ×7. Loc. S.4. Fig. 41, left librigena. It.3407, ×8. Loc. S.7. Fig. 42, latex cast of fragment of largest available cranium, with very long, flat border. Eye ridges are distinct, but median plectrum is little more than a wide (sag.) median depression in front of the glabella, and anterior border furrow and false border furrow are much reduced. It.3374, ×2.5. Loc. S.4. See also Figs 45–49.

**Figs 43–44** *Chelidonocephalus* sp. Loc. S.15. Figs 43a, b, dorsal and anterior views of incomplete exfoliated cranium. It.2139, ×6. Fig. 44, incomplete large cranium in which anterior border is relatively short (sag.); eye ridges, parafrontal band and glabellar furrows are almost indiscernible. It.2128, ×7.







*C. anatolicus* by its wider fixigenae, with eyes set farther forwards, and longer (tr.) incised portions of the border furrow. The median length of the frontal area is approximately one-third of the cranidium in the holotypes of *C. anatolicus* and of *C. alifrons*, but is proportionately greater in larger cranidia of *C. alifrons* as shown in Figs 39b and, particularly 42. The parafrontal lobe and plectrum are of similar size and development in both species, but the rearward curvature of the border furrow to the outer ends of the plectrum in *C. alifrons* has not been demonstrated in *C. anatolicus*. *Chelidonocephalus preannulatus* has a shorter anterior border and longer palpebral lobes than *C. anatolicus*, and the front of the glabella is proportionately narrower (tr.); as in *C. alifrons*, the backward curve of the border furrow to the prelabellar furrow is clearly seen.

The hypostoma of the type species of *Chelidonocephalus*, *C. alifrons*, has not been described; a single example attributed to *C. preannulatus* Fortey & Rushton (1976 : 338; pl. 9 figs 3, 4) is very different from the Derik material and is not congeneric. The Iranian specimen lacks posterior wings, the rim-like lateral and posterior borders are continuous, the anterior wings are long (tr.) and pointed and the middle furrow is set just behind the centre of the hypostoma. A small hypostoma attributed to *Koldiniella mitrella* Sivov, 1955 by Fortey & Rushton (1976 : pl. 10, fig. 16), though incomplete frontally, more resembles that of *Chelidonocephalus* as interpreted from the Derik material, but the posterior lobe of the middle body is proportionately larger.

For an account of pygidia assigned questionably to *Chelidonocephalus anatolicus*, see discussion of *Derikaspis toluni* (p. 31).

### *Chelidonocephalus* sp.

Figs 43a, b, 44

FIGURED MATERIAL. It.2128 (Fig. 44), It.2139 (Figs 43a, b).

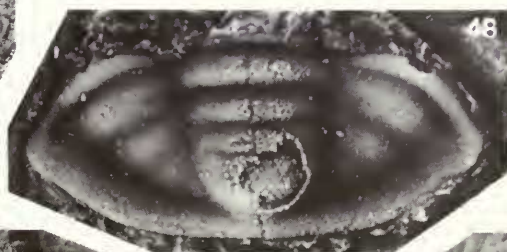
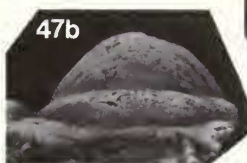
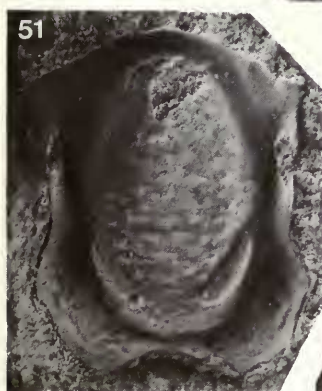
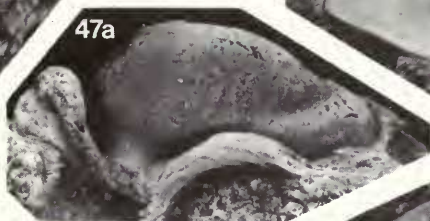
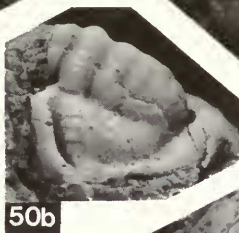
HORIZON AND LOCALITY. 190 m above the base of the Sosink Formation, at loc. S.15.

DESCRIPTION AND DISCUSSION. One of two figured cranidia (Fig. 44), with median length of 8 mm\*, has the anterior border proportionately shorter than that of *Chelidonocephalus anatolicus* (estimated 22% of median length compared with 28%); the false border furrow, eye ridges, parafrontal lobe, median plectrum and anterior pits are more weakly developed or almost indiscernible. These features are most distinct on a slightly larger cranidium (Figs 43a, b) which shows, in addition, bilobation of the frontal glabellar lobe, traces of a low median ridge on the glabella, a distinct occipital tubercle, bifurcating but very shallow 1p glabellar furrows and an incised, relatively long (tr.) border furrow which extends adaxially until almost in line with the axial furrows. In both specimens the surface of the exoskeleton is ornamented, at least in part, with fine granules. Coarser granulation covers most of the glabella of *Chelidonocephalus preannulatus* Fortey & Rushton (1976 : 338) from Iran, a species which differs also in having the plectrum better defined, particularly laterally, and a more tapered glabellar outline.

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**Figs 45–49** ? *Chelidonocephalus anatolicus* sp. nov. Figs 45a, b, dorsal and posterior views of partially exfoliated pygidium. It.2294,  $\times 3$ . Loc. S.2. Fig. 46, incomplete hypostoma. It.3390,  $\times 8$ . Loc. S.7. Figs 47a, b, lateral and posterior views of incomplete hypostoma. It.3409,  $\times 8$ . Loc. S.7. Fig. 48, small pygidium. It.3402,  $\times 20$ . Loc. S.7. Figs 49a–c, left lateral, dorsal and posterior views of pygidium. It.3405,  $\times 6$ . Loc. S.4. See also Figs 37–42.

**Figs 50–51** ? *Derikaspis toluni* gen. et sp. nov. Figs 50a–c, posterior, left posterolateral and dorsal views of partly exfoliated pygidium. It.3399,  $\times 5$ . Loc. S.11. Fig. 51, dorsal view of hypostoma showing tubercles on anterior lobe of middle body. It.3370,  $\times 5$ . Loc. S.4. See also Figs 52–59.





*Chelidonocephalus* has not been recorded other than from Iran and SE Turkey but may be represented in the Montagne Noire, SW France. Undetermined cranidia described by Courtessole (1973: 218; pl. 26, figs 8–11) from Niveaux H and I (highest Middle Cambrian of that region), though tectonically deformed, appear to show the salient features of the genus, including true and false border furrows and, possibly, a plectrum.

### Genus *DERIKASPIS* nov.

**DIAGNOSIS.** Glabellar outline subtrapezoidal, moderately tapered anteriorly where frontal glabellar lobe is slightly bilobed and includes poorly-defined parafrontal band. Conspicuous, high palpebral lobes, set behind centre with reference to glabella, are linked to frontal glabellar lobe by distinct, straight eye ridges. Median tubercle on occipital ring. Occipital furrow deepest abaxially. 1p and 2p lateral glabellar furrows very shallow, the 1p furrows bifurcating adaxially to delimit pair of large, intermediate lobes; 3p furrows absent or suggested by traces immediately behind the eye ridges. Incised anterior border furrow developed only abaxially, behind broad (sag.), shallow, false border furrow; remainder of anterior border forms wide (sag.), flat brim. Pair of long (tr.) anterior pits sited abaxially in preglabellar furrow and behind extremities of subelliptical median plectrum, which may be moderately defined or almost indistinguishable. Surface of cranidium ornamented with variable combination of granules and tubercles of different sizes.

**TYPE SPECIES.** *Derikaspis toluni* sp. nov.

**OTHER SPECIES.** *Jincella ? brianensis* Courtessole, 1973.

**DISTRIBUTION.** Middle Cambrian, SE Turkey and SW France.

### *Derikaspis toluni* sp. nov.

Figs 52–59, ?Figs 50–51

**HOLOTYPE.** It.3363 (Figs 53a–c).

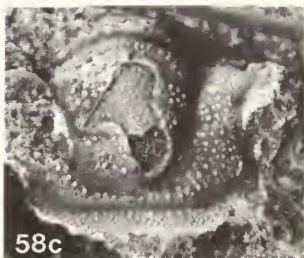
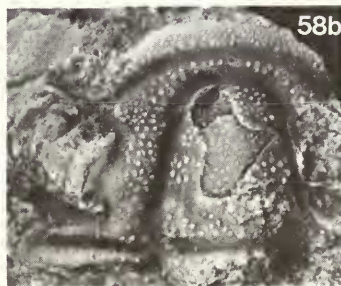
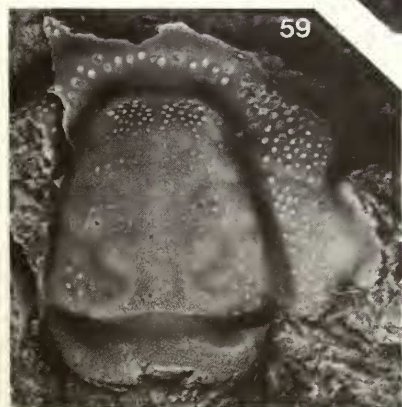
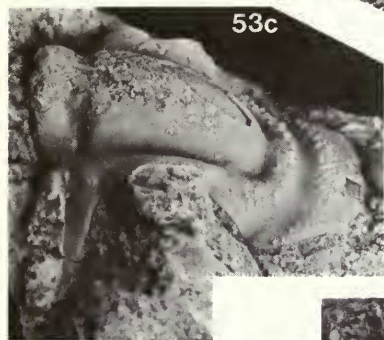
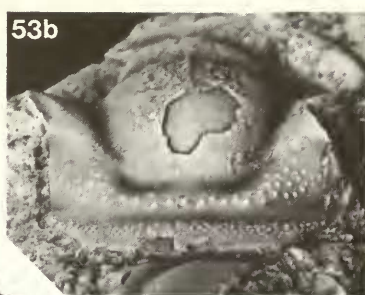
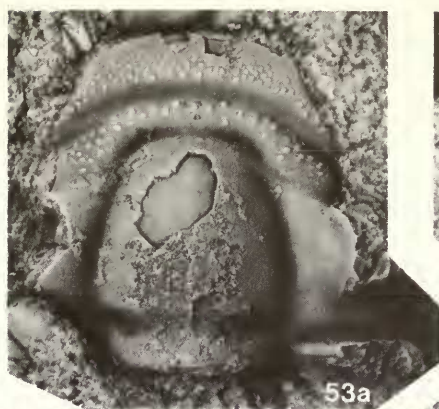
**OTHER MATERIAL.** It.1171 (Fig. 55), It.3391 (Fig. 59), It.3392 (Fig. 52), It.3393 (Fig. 56), It.3396 (Fig. 54), It.3408 (Fig. 57), MTA coll. unnumbered (Figs 58a–c). Also 13 specimens (11 cranidia) from S.1, 25 specimens (18 cranidia) from S.2, 29 specimens (16 cranidia) from S.3, 17 specimens (13 cranidia) from S.4, 16 specimens (7 cranidia) from S.5, 2 cranidia from S.10, 13 specimens (6 cranidia) from S.11, 22 specimens (18 cranidia) from S.12, one fragment of cranidium and two of librigenae from S.13 and two fragments of cranidium from S.16; most of the above unfigured material is incomplete. Pygidium It.3399 (Figs 50a–c) and hypostoma It.3370 (Fig. 51) are referred questionably to the species.

**HORIZONS AND LOCALITIES.** *Derikaspis toluni* was found at locs S.1, S.2, S.3, S.4 and S.5 in the area NW of Sosink, and at S.10, S.11, S.12, S.13 and S.16 in the stream valley north of the village. Stratigraphically these range from 18 m to 225 m above the base of the Sosink Formation. The holotype is from S.3.

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**Figs 52–59** *Derikaspis toluni* gen. et sp. nov. Fig. 52, incomplete cranidium ornamented with coarse tubercles. Note slightly larger tubercles on frontal glabellar lobe. It.3392,  $\times 3$ . Loc. S.11. Figs 53a–c, dorsal, anterior and oblique right lateral views of cranidium. Note reduction in ornamentation behind eye ridges. **Holotype**, It.3363,  $\times 4$ . Loc. S.3. Fig. 54, part of right librigena showing librigenal spine and granulose surface. It.3396,  $\times 3$ . Loc. S.12. Fig. 55, incomplete, almost exfoliated, large cranidium. It.1171,  $\times 2.5$ . Loc. S.12. Fig. 56, fragmentary cranidium exhibiting distinct parafrontal band. It.3393,  $\times 2$ . Loc. S.2. Fig. 57, large right librigena with strongly ornamented surface. It.3408,  $\times 3$ . Loc. S.12. Figs 58a–c, oblique left lateral, dorsal and anterior views of small cranidium with well-developed ornamentation of tubercles. MTA coll., unnumbered,  $\times 4.5$ . Loc. S.3. Fig. 59, incomplete large cranidium showing adaxial bifurcation of 1p glabellar furrows to encompass intermediate glabellar lobes. The distinctly individual ornamentation of the frontal glabellar lobe behind the line of the eye ridges, and its incipient bilobation immediately behind the parafrontal band, are clearly visible. It.3391,  $\times 3$ . Loc. S.11.





| DIMENSIONS (in mm).                          | It.3363 | It.1171 | It.3391 | MTA Coll. |
|----------------------------------------------|---------|---------|---------|-----------|
| Median length of cranium                     | 11.7    | 24.5    | —       | 7.6       |
| Basal breadth of cranium                     | 17.4*   | —       | —       | 12.5      |
| Median length of glabella and occipital ring | 16.2    | 17.3    | 12.7    | 5.6       |
| Basal breadth of glabella                    | 6.1     | 12.7    | 9.5     | 4.0       |
| Maximum breadth of frontal area              | 9.3     | 23.2*   | 15.3*   | 6.2       |
| Distance across palpebral lobes              | 12.0*   | —       | 20.8*   | 9.4*      |

**DESCRIPTION AND DISCUSSION.** The new genus is apparently closely related to *Chelidonocephalus*, and features common to both include bifurcate 1p lateral glabellar furrows, eye ridges and poorly-defined parafrontal lobe, border furrow deepest abaxially and a false border furrow. *Derikaspis* is distinguished as follows. The surface of small cranidia is always ornamented with tubercles while that of large specimens may be all or partly tuberculate, but is never totally smooth or finely granulate as in *Chelidonocephalus*. The false border furrow is well defined and deep, whereas in *Chelidonocephalus* it is shallow and may be indistinct; the anterior border is consistently shorter (sag.) at all stages of development, and particularly so in large cranidia. Well-developed intermediate lobes like those of *Derikaspis* are also found in *Iranoleesia pisiformis* (King, 1937) (see Fortey & Rushton 1976 : esp. pl. 9, figs 8, 9); they are present but much less evident in *Chelidonocephalus*.

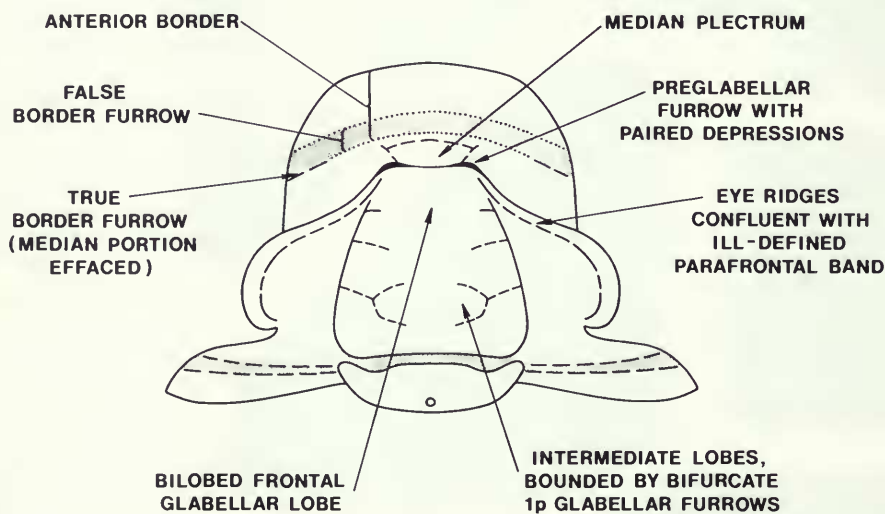


Fig. 60 Outline drawing of cranidium of *Derikaspis toluni* gen. et sp. nov., showing structural elements discussed in text. Ornamentation omitted.

Librigenae of *Chelidonocephalus anatolicus* and *Derikaspis toluni* are closely similar in shape, and in all cases the lateral and posterior border furrows join at the genal angle to form a single furrow that dies out along the librigenal spine. Those of *C. anatolicus* invariably have a smooth surface but in the case of *D. toluni* the genal field (Fig. 57) is ornamented with coarse tubercles, though these are sometimes less well developed, while the lateral border carries small tubercles that become still smaller towards the margin. Associated hypostomata and pygidia of the two species are also remarkably alike, and for the present are separated mainly on the basis of the ornamentation, those with a tuberculate surface being assigned to *D. toluni*. Evidence of the hypostoma is sparse, but a well-preserved specimen assigned questionably to *D. toluni* (Fig. 51) has the coarsely tuberculate middle body proportionately



narrower and more tapered frontally than in examples (Figs 46, 47a, b) referred, also questionably, to *C. anatolicus*. All these have in common the anterior border rim-like medially, dying out abaxially; the lateral border rim-like, subparallel opposite centre of hypostoma but dying out frontally towards pair of short (tr.), triangular, anterior wings and posteriorly to a large pair of posterior wings that are obliquely truncated posterolaterally; a broadly rounded median notch indenting the posterior margin; and the middle body divided by a shallow, parabolic middle furrow into two markedly unequal lobes, the posterior of which is the smaller and carries traces of a pair of maculae.

Pygidia assigned questionably to the two species are more than twice as broad as long, with outline rounded posteriorly. Pleural fields are convex, declining steeply to the ill-defined border, bounded by a shallow border furrow that becomes still shallower at the axial line. The clearly differentiated anterior half ribs, transversely straight near the axial furrows but curving backwards abaxially and truncated by a pair of articulating facets, are followed by two weakly-defined pairs of ribs; the subparallel pleural furrows become markedly shallower outside the pleural fields. The prominent, straight-sided, slightly tapered axis has a frontal breadth about one-third, or slightly less, that of pygidium. There are three or four transversely straight axial rings, the first two of which are most clearly defined, and on internal moulds (Figs 45a, 49c) the small terminal piece is seen linked by a very short postaxial ridge to the medially thickened border. Two pygidia from the Mila Formation attributed by Fortey & Rushton (1976 : pl. 9, figs 7, 11) to *Chelidonocephalus preannulatus* and, possibly, *C. alifrons* do not belong with *Chelidonocephalus* if the Turkish material is correctly interpreted. The Iranian specimens, though incomplete, are proportionately longer, have more axial rings and a less well defined terminal piece, and the border appears to be broader and flatter.

The other known occurrence of *Derikaspis* is in Niveau H of the Montagne Noire, SW France, where *Jincella ? brianensis* Courtessole (1973 : 174; pl. 17, figs 2–4) is considered here to be congeneric with *D. toluni*. Courtessole's specimens are most closely comparable with a much smaller Turkish specimen (Figs 58a–c) but have wider fixigenae, a larger development of tubercles in front of the furrow representing the plectrum, and apparently less well developed anterior pits. In larger cranidia the differences are considerable; compare Fig. 55, 24.5 mm long, with Courtessole's pl. 17, fig 3, *c.* 21 mm long. *D. toluni* exhibits much reduced ornamentation of both glabella and fixigenae, a wider (sag.) false border furrow, a shorter (sag.) anterior border and weaker glabellar furrows.

#### Family ANDRARINIDAE Raymond, 1937

##### Genus *HOLASAPHUS* Matthew, 1895

TYPE SPECIES. By monotypy, *Holasaphus centropyge* Matthew, 1895.

##### *Holasaphus mesopotamicus* Dean, 1972

1972 *Holasaphus mesopotamicus* Dean: 274; pl. 1, fig. 7; pl. 11, figs 1–7.

Although not refigured in the present account, the species is included because the type material came from the Sosink Formation in the area north of Sosink. The horizon was estimated to lie some 500 m above the base of the Sosink Formation as interpreted by Kellogg (1960) and the occurrence is therefore relevant to an assessment of the formation's age.

*Holasaphus* has, as yet, been reported from only two regions. In its type area of Cape Breton Island, Nova Scotia, eastern Canada, *H. centropyge* (see accounts by Hutchinson 1952 : 25, 26, 104; Dean 1972 : 274) was found in strata containing *Paradoxides abenacus* Matthew, 1886, a species stated by Hutchinson to be indicative of the *Paradoxides hicksii* Zone, approximately in the middle part of the Middle Cambrian (Cowie *et al.* 1972 : 10; pl.



5). *Holasaphus mesopotamicus* is an apparently younger species and its age, judged on that of the trilobites in the lowest Sosink Formation, is probably late Middle Cambrian.

Howell (*in* Moore 1959 : O261) placed *Holasaphus* in the Andrarinidae. The type species of *Andrarina*, *A. costata* (Angelin, 1854), was redescribed by Westergård (1948 : 14) and is characteristic of, though uncommon in, the *Lejopyge laevigata* Zone, highest Middle Cambrian, of Sweden. A cranidium preserved in shale from eastern Newfoundland and illustrated by Poulsen & Anderson (1975 : 2071; pl. 1, fig. 1) strongly resembles *H. mesopotamicus* and may be of broadly comparable age.

### Family uncertain

#### Genus & species undetermined A

Figs 64a-c, ?65

FIGURED SPECIMENS. It.3378 (Figs 64a-c) from loc. S.7, 135 m above the base of the Sosink Formation. It.2121 (Fig. 65), from loc. S.11, 90 m above the base of the Sosink Formation, is referred questionably to the same form.

DIMENSIONS. It.3378: Median length of cranidium 6 mm\*, overall breadth of cranidium 8.3 mm, median length of combined glabella and occipital ring 4.3 mm\*, basal breadth of glabella 3.1 mm, distance across palpebral lobes 6.5 mm\*.

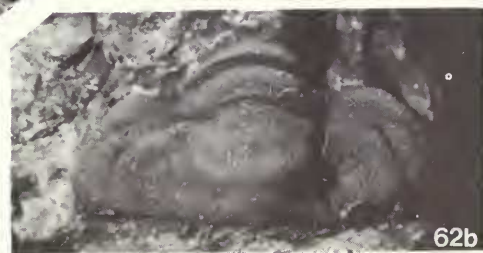
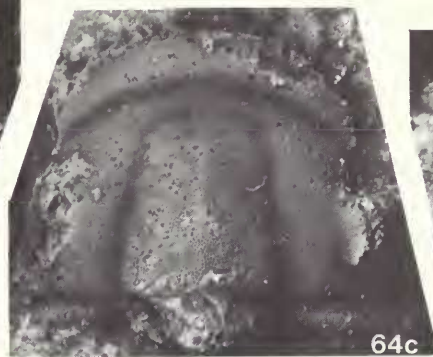
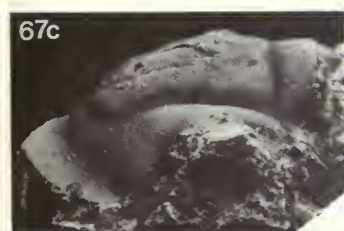
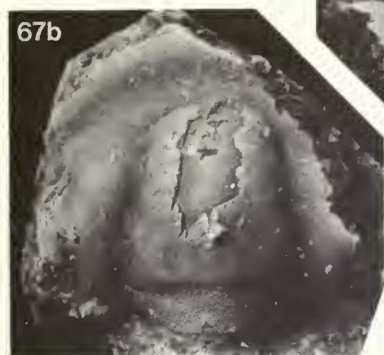
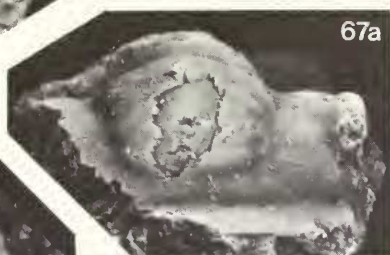
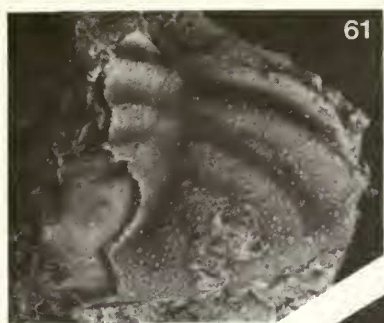
DESCRIPTION AND DISCUSSION. The cranidium is of low convexity, both longitudinally and transversely, with approximately three-quarters of the median length occupied by the combined glabella and occipital ring. The glabellar outline is trapezoidal, with straight lateral and frontal margins, and low axial ridge. Three unequal pairs of poorly-defined glabellar lobes are present. The low but conspicuous anterior border has a well-rounded outline and is widest (sag.) medially, where it occupies one-sixth of the cranidial length. The flat preglabellar field is half as wide (sag.) as the anterior border. Small palpebral lobes are set behind the centre with reference to the glabella. A spine base is possibly present on the occipital ring. Most of the surface of the exoskeleton is ornamented with conspicuous, small, closely-spaced pits. Pits are absent from both the axial furrows and the otherwise almost indistinguishable glabellar furrows; they are present on the posterior half of the anterior border but die out frontally, where the intervening areas fuse to produce low, anastomosing ridges subparallel to the margin. The low axial ridge of the glabella is traversed by pitting and is sited in line with a slight shallowing of the preglabellar furrow; the preglabellar field shows traces of low, scattered tubercles, but no pits. The surface of the surviving right palpebral lobe is pitted and almost level with that of the adjacent fixigena. The anterior branches of the facial suture diverge gently forwards to cut the border furrow and then curve adaxially to meet the anterior margin approximately in line with the axial furrows; the posterior branches curve backwards more strongly near the posterior margin.

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**Figs 61-63** *Conocoryphe* (s.l.) sp. Fig. 61, fragmentary pygidium. It.1148,  $\times 4$ . Loc. S.5. Figs 62a, b, right lateral and dorsal views of small pygidium. It.1144,  $\times 10$ . Loc. S.1. Figs 63a-c, left lateral, posterior and dorsal views of partly exfoliated pygidium. It.3403,  $\times 5$ . Loc. S.13. See p. 12.

**Figs 64-65** Genus & species undetermined A. Figs 64a-c, anterior, left lateral and dorsal views of cranidium. It.3378,  $\times 7$ . Loc. S.7. Fig. 65, incomplete cranidium referred questionably to species. Specimen tilted backwards slightly to show axial ridge on glabella. It.2121,  $\times 10$ . Loc. S.11.

**Figs 66-67** Genus & species undetermined B. Fig. 66, incomplete slightly broken cranidium. It.3371,  $\times 8$ . Loc. S.4. Figs 67a-c, anterior, dorsal and oblique left lateral views of incomplete cranidium. It.3376,  $\times 7$ . Loc. S.7.





No satisfactory assignment of this material has yet proved possible but a general comparison may be made with the type species of *Manchuriella* Resser & Endo, *M. typa* Resser & Endo (1937 : 241; pl. 36, figs 3–8) from the Middle Cambrian of Manchuria, redescribed by Lu *et al.* (1965 : 298; pl. 53 figs 5–7) and assigned to the Proasaphiscidae. Comparison may particularly be made with Resser & Endo's 1937: pl. 36, figs 3, 5; their description noted the presence of three pairs of shallow lateral furrows and a longitudinal ridge on the glabella. The exoskeleton of the Chinese species was said to be smooth, apart from an occipital node which cannot be satisfactorily demonstrated on the incomplete occipital ring of the present specimen. Other features distinguishing the Turkish species from *Manchuriella typa* are the longer (sag.) anterior border, shorter (sag.) preglabellar field, and narrower (tr.) fixigenae.

A small cranidium, It.2121 (Fig. 65), resembles It.3378 in the form of the anterior border and preglabellar field, the glabellar outline, and the divergent anterior branches of the facial suture; there is a suggestion of an axial ridge. On the other hand the glabella is proportionately shorter and more convex, the anterior border is thicker and less arched in outline, the palpebral lobes are larger, and there is no evidence of ornamentation. The specimen is referred only questionably to the same genus and species.

#### Genus & species **undetermined B**

Figs 66, 67a–c

FIGURED SPECIMENS. It.3371 (Fig. 66), from loc. S.4; It.3376 (Figs 67a–c) from loc. S.7. The stratigraphic horizons are, respectively, 80 m and 135 m above the base of the Sosink Formation.

DESCRIPTION AND DISCUSSION. The two fragmentary cranidia have a glabellar outline which tapers gently to the rounded frontal glabellar lobe. Short palpebral lobes are set moderately close to the glabella and the anterior branches of the facial suture diverge to cut, at points longitudinally in line with the palpebral lobes, an anterior border that is low in profile, broadly rounded in plan, and separated from the glabella by a narrow (sag.), flat, preglabellar field. Three inequized pairs of glabellar lobes are delimited by shallow lateral glabellar furrows, the 1p pair of which, in the case of the larger specimen (It.3371), bifurcate adaxially to produce intermediate lobes. The occipital ring narrows (exsag.) distally. Surface, excluding furrows, ornamented with closely-packed, fine granules, some of which are arranged in anastomosing lines.

Some features of the present material are found in three species of *Liostracus* (Agaso) described by Cobbold & Pocock (1934 : 359–362) from the *Paradoxides forchhammeri* Grit of the Wrekin district, Shropshire. All the British species have a tapered glabellar outline, a distinct preglabellar field, and an anterior border which may be slightly or strongly rounded in plan view. The sharply-defined, flat anterior border and steeply declined preglabellar field, particularly of the type species *L. (A.) rushtonensis* Cobbold & Pocock (1934 : pl. 45, fig. 3b), may be compared with Fig. 67c, though the low transverse convexity of the glabella in all the British species differs from that of the Turkish material.

#### Age and relationships of the trilobites

The affinities of the Sosink Formation's trilobites lie for the most part with SW Europe and the Mediterranean region, but certain genera reflect the proximity of Iranian faunas to the east, though the latter do not include paradoxidids.

The Middle Cambrian of the Montagne Noire, SW France, was divided by Courtessole (1967a) into eight parts, termed 'Niveaux', or levels, and designated successively A to H on the basis of the vertical ranges of their contained trilobites. More detailed ranges of genera and species were given later (Courtessole 1973), and a further level, Niveau I, was added, overlain, apparently disconformably, by Tremadocian strata termed Niveau J. The faunas



have much in common with those of northern Spain, where Sdzuy (1971) introduced successive 'niveles', or horizons, of *Conocoryphe ovata*, *Acadolenus*, *Badulesia*, *Pardailhanian* and *Solenopleuropsis*, followed by a 'Piso sin Solenopleuropsidae'. Vertical ranges of species were given, though no formal zones were designated, and Sdzuy proposed a provisional correlation between the French and Spanish sequences, together with those in Sweden and eastern Newfoundland. Sdzuy (1971: table 2) correlated Courtessole's Niveau A with the topmost quarter of the *Badulesia* horizon and approximately the lower half of the *Pardailhanian* horizon; Niveau B was equated with the upper half of the *Pardailhanian* horizon and the lowest third of the *Solenopleuropsis* horizon. Courtessole's subsequent work (1973 : table 3) indicates that *Pardailhanian* ranges through the whole of Niveau A in the Montagne Noire, where the Middle Cambrian succession is clearly incomplete. *Badulesia*, represented by a single species, *B. granieri* (Thoral), occurs only in the lower half (A<sub>1</sub>) of Niveau A and *Solenopleuropsis* extends from the base of Niveau B to the top of Niveau F. Niveaux G to I thus correspond to at least part of Sdzuy's 'Piso sin Solenopleuropsidae'.

*Solenopleuropsis marginata marginata* from the lowest available fossiliferous level in the Sosink Formation is taken to indicate part of the highest third of the north Spanish *Solenopleuropsis* horizon, in accordance with Sdzuy's (1971: table 1) recorded range of the subspecies there. Although *S. marginata* has not been reported from France, the Sosink record probably corresponds approximately to Niveau F there. It is from Niveaux F and H that the so-called 'oculé' forms of *Conocoryphe* (*Conocoryphe*) are known in the Montagne Noire. In Spain *C. (C.) sdzuyi* Courtessole (1976b) was recorded originally, as *C. (C.) pseudooculata* Miquel, by Sdzuy (1971 : table 1), from the highest part of the *Solenopleuropsis* horizon and the lowest 'Piso sin Solenopleuropsidae'. All these correspond at least approximately to the occurrence of *C. (C.) caecigena* within a restricted part (20 m) of the Sosink Formation and the group may have some potential in correlation.

*Paradoxides* (*Eccaparadoxides*) is widely distributed in the Mediterranean-Bohemian region, and ranges throughout the incomplete Middle Cambrian of the Montagne Noire, where certain species are restricted in their vertical distribution (Courtessole 1973). *P. (E.) remus* has not yet been found elsewhere but, judged on evidence in the lowest Sosink Formation, may have evolved from the apparently earlier *P. (E.) pradoanus*, recorded by Sdzuy (1971 : table 1) from the highest third of the *Pardailhanian* horizon and lowest two-thirds of the *Solenopleuropsis* horizon in Spain.

*Dorypyge* is a widespread genus, found mostly in the Middle Cambrian of both China and western Europe, and *D. terneki* contributes little evidence of age, though its resemblance to *D. aenigma* (Linnarsson), from the *Solenopleura brachymetopa* Zone of Sweden, was noted on p. 14. *Peronopsis fallax minor* (Brögger), also described from the Swedish *S. brachymetopa* Zone, may be cited as further evidence of a late Middle Cambrian age, but evidently had an extended vertical range, judged on the record of *P. fallax* cf. *minor* from the *Agnostus pisiformis* Zone, lowest Upper Cambrian, of central England (Taylor & Rushton 1972 : 19).

*Chelidonocephalus* is known elsewhere only from Iran, where a recent revision by Fortey & Rushton (1976) assigned *C. alifrons* King, 1937 to the *Dorypyge* Zone, highest subdivision of the Iranian Middle Cambrian as interpreted by Kushan (1973 : 125). The succeeding *Drepanura* Zone was said to contain, *inter alia*, *Koldiniella mitella* Sivov, 1955, indicative of lowest Upper Cambrian, *Chelidonocephalus preannulatus* Fortey & Rushton (1976 : 338) and an unnamed species of *Dorypyge*, in this instance ranging upwards from its named zone. The occurrence near Sosink of *Chelidonocephalus* with and above *Solenopleuropsis* predates that in Iran and indicates that the vertical range is greater than was previously thought. The related new genus *Derikaspis* occurs elsewhere in France, where *D. brianensis* (Courtessole, 1973) is rare in Niveau H of the Montagne Noire.

An earlier summary of the Sosink Formation's trilobites (Dean 1975 : 364; figs 2, 8) provisionally correlated the formation with the middle half of the Middle Cambrian, an assessment I now consider too low, judging from published correlations of the Scandinavian, Spanish and French successions. Within the shaly lowest 193 m of the Sosink Formation, the

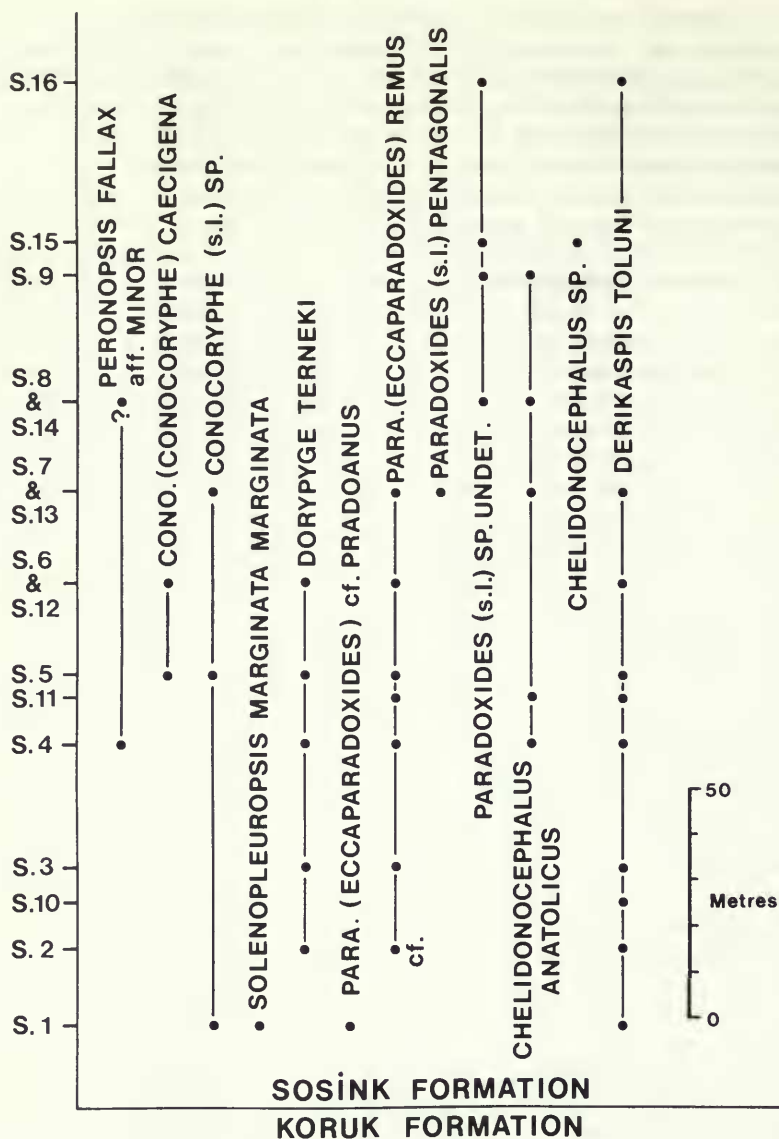


Fig. 68 Distribution of trilobites in lowest part of Sosink Formation. Locality numbers refer to Fig. 1, p. 3.

oldest fossiliferous horizon, S.1, is correlated with the highest strata containing *Solenopleuropsis* in both the Montagne Noire (Niveau F) and northern Spain, and thus with the highest part of the *Paradoxides paradoxissimus* 'Stage' of Sweden. A correlation of higher fossiliferous horizons in the shales with the lower two-thirds of the *Paradoxides forchhammeri* 'Stage' is suggested by the resemblance of *Peronopsis fallax* aff. *minor* and *Dorypyge terneki* to material from the *Solenopleura brachymetopa* Zone, and receives general support from the presence of *Derikaspis* in Niveau H of the Montagne Noire.

Fossils are uncommon and poorly preserved in the highest shales but undetermined fragments of *Paradoxides* (s.l.) at S.15, where they are accompanied by *Chelidonocephalus* sp., are evidence of a Middle Cambrian age. Fossils become still rarer in the overlying 865 m of sandstones, siltstones and silty shales which make up the remaining Sosink Formation as measured by Kellogg (1960). The significance of *Holasaphus mesopotamicus* about 500 m



above the base of the formation has already been discussed (Dean 1972); in spite of the absence of paradoxidids, a Middle Cambrian age still appears likely by analogy with *Holasaphus* in eastern Canada and the resemblance of *H. mesopotamicus* to *Andrarina costata* (Angelin) from the *Lejopyge laevigata* Zone of Sweden. There is as yet no evidence as to whether the upper half of the Sosink Formation is also of Middle Cambrian age or extends into the Upper Cambrian. Elsewhere in Turkey the faunas of the lower Sosink Formation may be represented in the Yerlikaş Formation (Ketin 1966 : 80) of the Penbeğli-Tut area, about 240 km west of Derik, where paradoxidids and *Solenopleuropsis* have been reported (Dean 1975 : 364). A record of *Solenopleuropsis* (Dean in Dean & Monod 1970 : 418) from the red nodular limestone member, highest unit of the Çal Tepe Formation near Seydişehir, is now known to be incorrect: the specimen in question is a fragment of *Pardailhanina* and the whole of the Çal Tepe Formation is older than the Sosink Formation.

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